HOUSATONIC RIVER

CONN., MASS. AND N.Y.

REPORT ON SURVEY FOR FLOOD CONTROL

UNITED STATES ENGINEER OFFICE
PROVIDENCE, RHODE ISLAND
JUNE 20, 1940

REPORT ON SURVEY

OF THE HOUSATONIC RIVER AND TRIBUTARIES

FOR FLOOD CONTROL

R E P O R T

UNITED STATES ENGINEER OFFICE
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WAR DEPARTMENT
UNITED STATES ENGINEER OFFICE
PROVIDENCE, RHODE ISLAND

June 20, 1940

Subject: Report on Survey of the Housatonic River and Tributaries for Flood Control.

To: The Chief of Engineers, U. S. Army, Washington, D. C. (Through the Division Engineer.)

SYLLABUS

The District Engineer finds that flood losses in the past along the main stem of the Housatonic River are not sufficient to justify reservoir protection; but that past losses and great potential flood damage in the basin of the Naugatuck River, the principal tributary of the Housatonic River, warrant protective works by the United States. He recommends the construction of a reservoir on the Naugatuck River above Thomaston, Connecticut, to protect the intensely developed Naugatuck Valley. He further recommends that this reservoir be built in the immediate future, since uninterrupted operation of the brass and other metal manufacturing facilities of this valley are vitally important to national defense. The estimated total cost of the reservoir is $5,150,000, this total cost to be borne by the United States. At thirty-two localities which suffered sharp flood losses local protective works were studied, but their costs exceed estimated benefits, except at two privately owned mills. No local protective works are recommended. There is no justification for improvement by the United States with respect to power development and irrigation or with respect to navigation beyond the existing project.

I. GENERAL

1. <u>AUTHORITY</u>. - House Document No. 308, Sixty-ninth Congress, first session, which was enacted into law, with modifications, in Section I of the River and Harbor Act of January 21, 1927, authorized a preliminary report on the Housatonic River. Pursuant to this act, a preliminary report was submitted by the District Engineer on June 25, 1931, and was printed in House Document No. 246, Seventy-second Congress, first session.

_a._ A review report was submitted on October 1, 1936, in compliance with a resolution approved and adopted by the Committee on Flood Control of the House of Representatives on April 2, 1936, as follows:

> "Resolved, by the Committee on Flood Control of the House of Representatives, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on the Housatonic River, Conn., submitted in House Document No. 246, 72nd Congress, first session, with a view to determining whether any modification of the recommendations contained therein is deemed advisable as a result of the recent severe floods."

_b._ This report is submitted in accordance with a favorable recommendation on the review report by the Board of Engineers for Rivers and Harbors, dated March 29, 1937, as follows:

> "The Board recommends a survey of the Housatonic River in Connecticut and Massachusetts to determine the advisability and cost of improvement and the local cooperation to be required."

In a letter dated July 30, 1937, the Chief of Engineers directed a survey of the locality as recommended by the Board of Engineers for Rivers and Harbors.

2. <u>SCOPE OF THE INVESTIGATION.</u> - This report presents the results of the preliminary examination and survey for flood control on the Housatonic River and its tributaries, and collateral studies covering pollution and additional storage for power, conservation, recreation, and sanctuary for wild life. It investigates one flood control reservoir on the Naugatuck River, three reservoirs on the upper Housatonic River, one reservoir on the Green River, and local protection works at numerous localities within the watershed. Data on hydrology and meteorology, geology, flood losses, pollution, power and conservation, and recreation, and the conclusions drawn from them, together

with descriptions, estimates, and economics of the proposed plan, are included in this report. Pertinent data, descriptions, and estimates in greater detail are given in the appendix.

3. PRIOR REPORTS.

a. A preliminary report was submitted June 25, 1931, under the provisions of House Document No. 308, Sixty-ninth Congress, first session, and covered the features of navigation, flood control, power development, and irrigation. It was entitled "Housatonic River, Connecticut, Massachusetts, and New York," and was printed in House Document No. 246, Seventy-second Congress, first session. In this report it was found that:

(1) Modification of the existing navigation project was not advisable.

(2) There was no flood problem.

(3) There was potential water power capable of being developed on an economical basis.

(4) Irrigation was not necessary.

(5) The navigation project could not be coordinated with power development, flood control, or irrigation.

This report gives a complete summary of all previous reports on the Housatonic River.

b. A review of House Document No. 246 on the Housatonic River was submitted by the District Engineer on October 1, 1936. This review discussed the Housatonic River with respect to flood control, based upon the information contained in House Document No. 246, various reports and investigations made by State and private agencies, and additional data gathered by this office during and after the flood of March 1936. In this report the District Engineer found that, in the portion of the Housatonic Watershed in Connecticut, conditions were such that damage from floods was not excessive; but that in Massachusetts large areas and populous centers are subject to overflow, and considerable loss results. A survey of that portion of the basin in Massachusetts was recommended to determine the economic feasibility of improvements for flood control and water conservation.

4. REPORTS OF OTHER AGENCIES. - The Massachusetts State Senate Document No. 289, entitled "Report of the Commission on Waterways and Public Lands on the Water Resources of the Commonwealth of Massachusetts," printed in March 1918, gives valuable physical data on the Housatonic River in Massachusetts. A summary of high-water marks observed on the Housatonic River in Massachusetts is available in "High Water Data, Flood of March 1936 in Massachusetts," and "High Water Data, Floods of March 1936 and September 1938 in Massachusetts," prepared by the Massachusetts Geodetic Survey. Following the flood of September 1938, a "Report of Investigation of September 1938 Flood" was prepared by a group of consulting engineers for the Department of Public Works of Massachusetts. This report presents maps, profiles, high-water data, damage statistics, and costs of stream clearance improvements for all streams within Massachusetts. Several reports on pollution in the Housatonic River have been published and are listed in appendix E. Various other reports have been published by the State Planning Boards of Connecticut and Massachusetts, and by town agencies, and have been of valuable assistance in the determination of experienced flood damages.

5. EXISTING PROJECT.

a. Federal.

(1) There has been no Federal improvement for flood control, and there is no existing Federal flood control project on the Housatonic River or its tributaries.

(2) The Housatonic River is navigable to Shelton, Connecticut. Navigation above Shelton is limited to craft of less than 3-foot draft which can pass the Shelton Dam by means of a canal and locks and proceed as far as Otter Rock, which is the head of navigation, some 3 miles above the dam and 16.5 miles from the mouth. The original project was adopted in 1871. In its present modified form it provides for a channel, 18 feet deep at mean low water and 200 feet wide, from the mouth to the lower end of Culvers Bar, a distance of about 5 miles, and thence 7 feet deep and 100 feet wide to Derby and Shelton, a distance of about 8 miles, and includes auxiliary structures to maintain and protect the channel. The present project is 29 percent complete.

b. Local improvements. - Following the September 1938 flood, the State of Massachusetts appropriated $1,000,000 for a state-wide project of channel clearing and waterway reconstruction in an act approved October 28, 1938. In many cases, the United States contributes to the cost of the projects since a large number of them receive Work Projects Administration funds for the work. Under the provisions of this act a channel-clearing and straightening project is contemplated in Pittsfield, Massachusetts, at a cost to the State of $75,000. The City of Pittsfield has budgeted an additional $40,000 to cover the cost of raising two bridges and eliminating other obstructions to the flow. An extensive channel improvement project sponsored by the City of Naugatuck, Connecticut, has been completed. It has been necessary to replace bridges at Pittsfield, Massachusetts, and at Torrington, Seymour, and Derby, Connecticut. The result of all these projects has been to increase the capacity of the stream channel at the points concerned. These completed and proposed projects will alleviate flood conditions in the immediate vicinity of each improvement, but will not provide complete protection against future floods. The reduction of total flood damages as a result of these projects will be a small percentage of the total damages in the entire basin.

6. MAPS.

a. The Housatonic River Watershed is completely covered by the standard quadrangle maps of the United States Geological Survey on a scale of 1:62,500. These maps were used in preparing the plan of the watershed, Plate No. 1. Various city maps are also available.

b. This office has prepared high-water profiles along both the Housatonic and the Naugatuck Rivers. Small areas have been mapped in Waterbury, Connecticut, and Pittsfield, Massachusetts. Reservoir sites have been mapped at two locations near Thomaston, Connecticut, and one location near Dalton, Massachusetts.

c. At the request of the Providence United States Engineer Office, the United States Army Air Corps, in 1939, made airplane photographs of large portions of the Housatonic Watershed. These pictures are at an approximate scale of 1:12,000, and have been of value for reference in the preparation of this report.

II. DESCRIPTION OF HOUSATONIC BASIN

7. GENERAL. - The Housatonic River and its tributaries drain an area of 1948 square miles in western Connecticut, western Massachusetts, and eastern New York. The Housatonic River is a tidal estuary from Long Island Sound, four miles east of Bridgeport, Connecticut, to Derby and Shelton, Connecticut, where it receives the fresh water discharge of the Naugatuck and Housatonic Rivers.

8. LOCATION AND SIZE. - The Housatonic River Basin lies principally in western Connecticut. The river has its source in western Massachusetts near Washington Station. The Naugatuck River is the principal tributary and has its source in western Connecticut, north of Torrington. The Tenmile River lies in eastern New York. The drainage area, by States, is as follows:

Connecticut	1,234 square miles
Massachusetts	499 square miles
New York	215 square miles
Total	1,948 square miles

The watershed is roughly elliptical in shape, having a maximum width in an east-west direction of 35 miles, and a maximum length in a north-south direction of 98 miles. Plates Nos. 1 and 2 show a general watershed map and profiles of the Housatonic and Naugatuck Rivers.

9. TOPOGRAPHY. - The Housatonic Basin is hilly, with wooded hilltops and cleared valleys. The latter are largely devoted to farming and dairying in the Housatonic Valley, and to cities and manufacturing in the Naugatuck Valley. The elevations vary from mean sea level to a maximum of about 2660 feet above mean sea level along the northern divide of the watershed. The hills along the watershed rise to heights about 1000 feet above the valley of the Housatonic River. The average elevation

is approximately 920 feet above mean sea level. The topography of the entire drainage area is shown on United States Geological Survey maps on a scale of 1:62,500 with 20-foot contour intervals.

10. DESCRIPTION OF MAIN STREAM. - The Housatonic River rises near Washington Station, Massachusetts, in the heart of the Berkshire Hills, and flows northward through Hinsdale to Dalton, thence southwest to Pittsfield in western Massachusetts. At Pittsfield it is joined by the West and Southwest Branches, and thence flows in a southerly direction for 132 miles across Massachusetts and Connecticut to its mouth in Long Island Sound, 4 miles east of Bridgeport, Connecticut. The river valley in Connecticut, from Falls Village southward, is narrow and flanked by hills on either side, with but little low-lying land. The exceptions to the latter are in the vicinity of Kent, where the valley is approximately one-half mile wide, and in the vicinities of New Milford and Stratford, where the widths are approximately one mile. Above Falls Village in Connecticut and in Massachusetts, the valley is in general much broader, varying from one to three miles in width. In the vicinity of Sheffield, Massachusetts, the wide valley is alluvial in character, and the river flows in a meandering course. The length of the river along its course from Pittsfield to the mouth is about 132 miles, and the fall is 960 feet, of which 315 feet occur in Massachusetts and 645 feet in Connecticut. In several places the river has cut through the gravel to the underlying ledge rock, over which it flows in abrupt falls of varying heights. While advantage has been taken of many such falls for the production of power for manufacturing plants and for the generation of electricity, there is still considerable head which is undeveloped. Below Shelton Dam the river is tidal for a distance of 13-1/2 miles to its mouth. Pertinent data concerning the Housatonic River are given in Table I, and a profile of the river is shown on Plate No. 2.

TABLE I

HOUSATONIC RIVER - DRAINAGE AREAS AND PERTINENT DATA

River	Drainage area, square miles	Miles from mouth of the Housatonic
Housatonic, at mouth	1,948	0
Housatonic, at Derby, Conn. (including Naugatuck River)	1,892	12
Housatonic, at Stevenson, Conn., U.S.G.S. Gage	1,545	19
Housatonic, at Bulls Bridge Dam, Conn.	784	53
Housatonic, at Falls Village, Conn., U.S.G.S. Gage	632	75
Housatonic, at Connecticut-Massachusetts State line	581	83
Housatonic, near Great Barrington, Mass., U.S.G.S. Gage	280	105
Housatonic, at Pittsfield, Mass. (including West Branch)	130	131
Housatonic, at Van Sickler Dam in Pittsfield, Mass.	71	132
Housatonic, at Coltsville, Mass., U.S.G.S. Gage	57	136
Naugatuck, at mouth	312	12
Naugatuck, near Naugatuck, Conn., U.S.G.S. Gage	246	24
Naugatuck, near Thomaston, Conn., U.S.G.S. Gage	72	43
Naugatuck, at Torrington, Conn. (including East Branch)	49	51
Hop Brook, at mouth	17	26
Mad, at mouth	26	30
Steel Brook, at mouth	17	33
Hancock Brook, at mouth	14	34
Branch of Naugatuck, at mouth	23	39
Leadmine Brook, at mouth	24	43
Pomperaug, at mouth	89	26
Shepaug, at mouth	157	32
Still, at mouth	72	41
Rocky, at mouth	41	45
Tenmile, at mouth	209	52
Salmon Creek, at mouth	40	74
Hollenbeck, at mouth	44	77
Blackberry, at mouth	47	82
Konkapot, at mouth	63	83
Hubbard and Schenob Brooks, at mouth	46	93
Green, at mouth	52	99
Williams, at mouth	43	105
West Branch, at mouth	59	131

11. DESCRIPTION OF TRIBUTARIES. - The most important tributaries of the Housatonic River are the Naugatuck, Shepaug, Still, Rocky, and Tenmile Rivers. There are many smaller tributaries which will not be discussed in detail in this paragraph. The most important single tributary is the Naugatuck River.

a. Naugatuck River. - The Naugatuck River is a non-navigable, shallow, rapid-flowing stream lying wholly in Connecticut and east of the Housatonic River. The drainage area is 312 square miles. The headwaters are within six miles of the Connecticut-Massachusetts State line, near Norfolk, where the watershed has an elevation of 1500 feet. The general direction of flow is southerly, through Torrington, Thomaston, Waterbury, Naugatuck, Beacon Falls, Seymour, and Ansonia, to Derby where it joins the Housatonic River at tidewater, about 12-1/4 miles from Long Island Sound. The drainage area is similar in shape and topographic features to the Housatonic Watershed. The river valley is narrow, with rocky hills rising on either side of the stream. There is a fall in the river of 529 feet from Torrington to Derby, some of which is utilized by manufacturing industries. Pertinent data concerning the Naugatuck River are given in Table I and a profile of the river is shown on Plate No. 2.

b. Shepaug River. - This stream has a long, narrow drainage area of 157 square miles lying wholly in Connecticut between the Housatonic and Naugatuck Rivers. The source is west of North Goshen, whence it flows in a southerly direction to its junction with the Housatonic River 10-1/2 miles below New Milford. It has an average slope of 30.5 feet per mile. The City of Waterbury has, by act of the State Legislature, secured the right to divert practically the entire run-off from 37 square miles of drainage area on the West Branch of the Shepaug River for its water supply. The economic value of the Shepaug River now lies principally in its use for water supply.

c. <u>Still River</u>. - This stream has a drainage area of 72 square miles. Its source is west of Danbury, whence it flows through the city and northwesterly to its confluence with the Housatonic River, two miles south of New Milford. There are numerous lakes and swamps about Danbury, the former being utilized as a form of municipal water supply.

d. <u>Rocky River</u>. - This stream has a drainage area of 41 square miles, lying north of Danbury and west of the Housatonic River, which it joins 1-1/2 miles above New Milford. It is the location of a pumped-storage hydroelectric station of the Connecticut Light and Power Company. A dam and dikes were built in the basin, creating a reservoir having 8.3 square miles of surface area. Further details are given in paragraph 17c.

e. <u>Tenmile River</u>. - This stream has a drainage area of 209 square miles, most of which lies in Dutchess County, New York. It joins the Housatonic River three quarters of a mile below Bulls Bridge, Connecticut. In the past it has been considered as a possible source of water supply for New York City, but the interstate character of the stream has prevented its development for this purpose.

12. <u>GEOLOGY</u>. - The Housatonic Watershed lies in the highland area of western Connecticut and Massachusetts. Rock formations are composed of steeply inclined crumpled and folded strata of schist, limestone, quartzite, and gneiss. These rocks are of sedimentary origin but they have been strongly metamorphosed, and in certain areas intruded by igneous materials. Throughout much of the upland area the overburden consists of a thin veneer of glacial till composed of a mixture of sand, silt, gravel, cobbles, and boulders. Extensive glacial deposits of stratified sand and gravel occur in terrace form throughout the bottoms and along the sides of valleys.

13. <u>POPULATION</u>. - Based upon the Federal Census of 1930, the population of the Housatonic Watershed is estimated at 383,900 for that year. The following table shows the population by States.

TABLE II

HOUSATONIC RIVER - POPULATION BY STATES

1930 Census

State	Population of drainage area	Population per square mile of drainage area	Population per square mile of entire State
Connecticut	290,700	236	333
New York	17,600	82	264
Massachusetts	75,600	152	528
Total	383,900	197	-

The population and the most important industries of the principal cities in the watershed, according to the Federal Census of 1930, are shown in Table III, on the following page.

TABLE III

HOUSATONIC RIVER - PRINCIPAL INDUSTRIES AND POPULATION OF MOST IMPORTANT CITIES AND TOWNS

1930 Census

City or town	Population	Principal industries
HOUSATONIC BASIN		
Dalton, Massachusetts	4,220 *	Paper and textile manufacturing; summer resort.
Pittsfield, Massachusetts	49,677	Electrical equipment, paper, and textile manufacturing.
Lee, Massachusetts	4,061 *	Paper manufacturing; summer resort.
Great Barrington, Massachusetts	5,934 *	Textile manufacturing; summer resort.
New Milford, Connecticut	4,700 *	Tobacco packing; wearing apparel; gold- and silver-plating; bleaching and dyeing of fabrics.
Danbury, Connecticut	22,261	Hat manufacturing; hat machinery; silver-plated goods.
Bethel, Connecticut	3,886 *	Hat, silk, and leather manufacturing.
Shelton, Connecticut	10,113	Radio parts; sealing and labeling machines; textiles; rubber goods.
Derby, Connecticut	10,788	Castings; forgings; machinery; textiles; rubber goods.
Stratford, Connecticut	19,212 *	Aeroplanes; brake linings; silver plating.
NAUGATUCK BASIN		
Torrington, Connecticut	26,040	Miscellaneous nickel-, silver-, and gold-plated goods; sheet and rolled brass; golf shafts; castings; machinery.
Thomaston, Connecticut	4,188 *	Clocks; brass goods; automatic machine products.
Watertown, Connecticut	3,000	Thread; rayon cloth; bakelite products
Waterbury, Connecticut	99,902	Miscellaneous brass, copper, and German silver products; clocks and watches; chemicals; machinery; recording instruments.
Union City, Connecticut	3,500	Electroplating and machining.
Naugatuck, Connecticut	14,315	Rubber goods; malleable iron; brass- and copper-plating; mirrors; machinery; aeroplanes.
Seymour, Connecticut	6,890 *	Brass and copper goods; hard rubber goods; edge tools; iron foundry.
Ansonia, Connecticut	19,898	Brass and copper goods; iron casting and general foundry business.

*Population of entire town.

14. <u>INDUSTRIES</u>. - The main types of industries in the watershed are those referred to in Table III. The principal industrial areas lie in New Haven, Fairfield, and Litchfield Counties, Connecticut, and Berkshire County, Massachusetts. Data concerning the manufacturing establishments in these counties, as given in the 1935 Censuses of the respective States, are stated in the following table:

TABLE IV

HOUSATONIC RIVER - MANUFACTURING ESTABLISHMENTS

1935 Census

County	Number of establishments	Number of workers	Value of finished goods
Fairfield, Conn.	805	57,411	$265,277,214
New Haven, Conn.	839	65,663	270,075,609
Litchfield, Conn.	104	10,018	33,884,685
Berkshire, Mass.	163	15,299	59,381,379
Total	1,911	148,391	628,618,887

15. <u>AGRICULTURE</u>. - For the counties which are drained in part by the Housatonic River, the Federal Census of 1930 gives the following agricultural data:

(Table V on following page)

TABLE V

HOUSATONIC RIVER - FARM PRODUCTS

1930 Census

County	Area of farm land, square miles	Value of livestock	Annual value of crops	Annual value of dairy products	Annual value of wool, poultry, and honey products	Total annual value of farm products
Fairfield, Conn.	222	$ 2,221,693	$ 3,029,061	$ 2,146,704	$ 1,423,586	$ 6,599,351
New Haven, Conn.	234	2,727,327	3,638,414	2,891,161	1,788,631	8,318,206
Litchfield, Conn.	437	3,963,552	2,604,193	3,789,639	1,433,366	7,827,198
Hartford, Conn.	390	3,822,193	15,519,215	3,490,353	1,881,957	20,891,525
Dutchess, N. Y.	528	4,282,898	3,766,579	3,769,556	1,221,585	8,757,720
Columbia, N. Y.	432	2,610,052	2,575,657	1,518,784	1,102,770	5,197,211
Berkshire, Mass.	392	2,138,839	1,466,534	1,853,411	794,470	4,114,415
Totals	2,635	21,767,554	32,599,653	19,459,608	9,646,365	61,705,626

16. TRANSPORTATION FACILITIES. - Railways, highways, and a navigable waterway provide all sections of the drainage area with adequate means of transportation for freight and passengers. The Berkshire Division of the New York, New Haven and Hartford Railroad follows the Housatonic River from the main line near Bridgeport, Connecticut, to Pittsfield, Massachusetts. The Naugatuck Division follows the Naugatuck River from Derby to Torrington. A branch of the New York, New Haven and Hartford Railroad connects Danbury, Connecticut, with Waterbury, Connecticut. The Harlem Division of the New York Central Railroad follows the Swamp River and the Tenmile River through the watershed in New York. The main line of the Boston and Albany Railroad crosses the upper end of the watershed via the valley of the Housatonic River and the Southwest Branch of the Housatonic River. The locations of the railroads are shown on Plate No. 1. In addition to the railroads, modern hard-surfaced highways are maintained throughout the Housatonic Basin, and provide adequate means of motor transportation. The Housatonic River proper is navigable from its mouth to Derby and Shelton, Connecticut. House Document No. 246, Seventy-second Congress, first session, outlines the existing channel depths for the Housatonic River, and gives statistical data on its commercial use.

17. DEVELOPMENT OF WATER RESOURCES. - The water resources of the Housatonic River have been extensively developed for the generation of power.

a. Housatonic River. - The difference in elevation of normal low water at the Massachusetts-Connecticut State line and the top of the storage dam at Hinsdale, Massachusetts, is about 777 feet, of which 517 feet are utilized for power, and an additional 13 feet for storage, leaving 247 feet undeveloped. The present installed power capacity is estimated at 10,435 horsepower distributed among 20 plants. The fall of the river in Connecticut is about 645 feet, of which 309 feet are developed for power, leaving 336 feet undeveloped. The present installed capacity is estimated at 63,700 horsepower at 5 plants. Summarizing the above, 826 feet of fall, out of a total of 1422 feet, are utilized in the development of 74,135 horsepower at 25 plants, and 13 feet are utilized for storage. The Rocky River plant of the Connecticut Light and Power Company, which pumps water from the main river but utilizes no head on it, is not included in this summary. Plate No. 1 and Table I of appendix A give the location and pertinent data concerning these developments.

b. Naugatuck River. - The difference in elevation of normal low water at Torrington, Connecticut, and mean tidewater at Derby, Connecticut, is 528 feet, of which 121 feet are utilized for power development. At the present time 115 feet of head are developed for storage, and 292 feet are undeveloped. The present installed capacity is estimated at about 2202 horsepower distributed among 7 plants. Plate No. 1 and Table I of appendix A give pertinent data on these developments.

c. Rocky River. - Although this river is but a small tributary of 41 square miles drainage area, it has been developed in a way to justify special comment. In addition to its steam plants and two hydroelectric developments on the Housatonic River, the Connecticut Light and Power Company operates a plant on the Rocky River which is termed a "pumped-storage, peak-load development." A dam near the mouth of Rocky River creates a reservoir having 8.3 square miles of surface area. The maximum capacity is 135,445 acre-feet, although the company engineers estimated the average yearly run-off at 34,435 acre-feet. The normal capacity is maintained by pumping from the Housatonic River against a head varying from 200 to 230 feet. The excess capacity is sufficient to control completely the 41 square miles of drainage area. Open and closed conduits combine to connect the reservoir with the powerhouse located on the Housatonic River, where pumping and generating apparatus is housed. Off-peak power developed at other hydroelectric stations of the Connecticut Light and Power Company is used to pump water into the reservoir from the Housatonic River. The reservoir is drawn upon to carry the peak load of the power system. The installed capacity of this plant is 32,000 horsepower. The company plans further hydroelectric development in the Housatonic watershed.

18. WATER SUPPLY AND OTHER DEVELOPMENTS. - The City of Waterbury, Connecticut, has utilized the headwaters of the Shepaug and a branch of the Naugatuck River as its water supply. A dam on the Shepaug River near Woodville creates a reservoir which is connected by a water-supply tunnel to the upper reservoir on the Branch of Naugatuck River. The City of Danbury, Connecticut, has utilized the headwaters of the Still River as its water supply. The City of Pittsfield, Massachusetts, has utilized several small tributaries around Pittsfield as its source of water supply. The City of Torrington has a water-supply dam on Hart Brook, a tributary of the Naugatuck River above Torrington. The City of Thomaston has a reservoir on a small tributary of the Naugatuck near Thomaston. There are many other dams on small tributaries, where water is impounded for condensing or processing purposes and pondage for small power developments.

19. RECREATION. - The Housatonic River Watershed in Massachusetts might be spoken of as one large summer resort. This region is often referred to as "The Heart of the Berkshires." Recreation and vacation facilities are highly developed in this region and are the principal source of income. Fishing is popular in the headwaters of the tributaries, and the many lakes and ponds in the basin provide ample facilities for fishing, boating, swimming, and camping.

20. WILD LIFE. - Within the Housatonic Watershed there are 16 State forest reservations in Massachusetts and 6 in Connecticut, in addition to abundant wooded sections. There are also numerous small State parks in Connecticut. These, in addition to numerous lakes and ponds, and the streams which are free from pollution, provide adequate sanctuary for wild life.

III. HYDROLOGY AND METEOROLOGY

21. <u>CLIMATE</u>. - The climate of the Housatonic Watershed is temperate. The winters and summers are greatly modified by the influence of the ocean. Near the coast many of the major storms of the winter season are in the form of rain. Freezing temperatures do not begin until about November 10th in the vicinity of Pittsfield, and a week or two later in the southern portion of the watershed. Freezing temperatures cease about March 25th in the southern part of the watershed, and about two weeks later in the northern part. The minimum temperature in the northern part of the watershed is -25 degrees Fahrenheit, and the maximum temperature in the southern part is 101 degrees. The mean annual temperature of the watershed, as shown in Table VI, is 48 degrees.

TABLE VI

HOUSATONIC RIVER - CLIMATOLOGICAL DATA

Station	State	Period of precipitation record	Average annual precipitation in inches*	Average annual snowfall in inches	Mean annual temperature in degrees Fahrenheit
Bridgeport	Conn.	1894 - date	46.95	35.5	50.6
Waterbury	Conn.	1887 - date	46.55	44.7	50.1
Cream Hill	Conn.	1897 - date	46.76	76.9	46.3
Falls Village	Conn.	1891 - 1902 1914 - date	43.24	56.9	47.3
Egremont	Mass.	1903 - 1911 1915 - date	42.38	--	--
Stockbridge	Mass.	1920 - date	43.93	--	--
Pittsfield	Mass.	1895 - date	41.23	61.2	46.2
Mean			44.44	55.0	48.1

*Including water equivalent of snow.

22. PRECIPITATION. - The average annual precipitation in the Housatonic Watershed is 44 inches, including the water equivalent of snow. The average annual precipitation is well distributed over the year, as shown in Table VII.

(Table VII on following page)

TABLE VII

HOUSATONIC RIVER - MEAN MONTHLY PRECIPITATION AND RUN-OFF IN INCHES

STATION	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Bridgeport, Conn.	3.99	3.76	4.15	3.92	3.64	3.46	4.24	4.52	4.01	3.79	3.53	3.94	46.95
Waterbury, Conn.	3.96	3.79	4.08	3.68	3.80	3.52	4.42	4.34	3.91	3.69	3.52	3.84	46.55
Cream Hill, Conn.	3.71	3.32	3.69	3.55	3.97	4.24	4.64	4.45	4.54	3.54	3.57	3.54	46.76
Falls Village, Conn.	3.10	3.14	3.25	3.18	3.74	3.94	4.55	4.28	4.41	2.97	3.37	3.31	43.24
Egremont, Mass.	3.12	2.83	2.78	3.35	3.33	4.29	4.39	4.65	4.12	3.32	3.27	2.93	42.38
Stockbridge, Mass.	3.16	2.60	3.39	3.55	3.48	4.60	4.25	4.55	4.64	3.11	4.11	2.49	43.93
Pittsfield, Mass.	3.05	2.75	3.46	3.06	3.08	3.86	4.28	4.15	4.04	3.10	3.27	3.13	41.23
Average	3.44	3.17	3.54	3.47	3.58	3.99	4.40	4.42	4.24	3.36	3.52	3.31	44.44
Run-off*	2.10	1.50	3.92	3.89	2.22	1.42	.74	.57	1.05	.78	1.27	1.46	20.92
Percent run-off to mean precipitation	61.0	47.3	110.7	112.1	62.0	35.6	16.8	12.9	24.8	23.2	36.1	44.1	47.1

* Computed as mean of run-off at Stevenson on the Housatonic River, and Naugatuck on the Naugatuck River, weighted according to drainage area.

23. SNOWFALL. - The average annual snowfall diminishes rapidly from western Massachusetts to Long Island Sound. As shown in Table VI, it varies from 35.5 inches to 76.9 inches, with a water equivalent of four to seven inches.

24. CHARACTERISTICS OF STORMS. - Two general types of storms occur in New England, continental storms and tropical hurricanes. The continental storms originate over the United States and southwestern Canada and move in an easterly and northeasterly direction. These storms occur in every season of the year. The tropical hurricanes originate over the Atlantic Ocean, including the Caribbean Sea and the Gulf of Mexico, and generally move in a westerly or northwesterly direction, recurving to the northeast as they approach the coast of the United States. This type of storm can be expected in any month, especially from May to December, but by far the greater number occur in August, September, and October. They seldom reach New England with destructive force, but when they do, excessive precipitation occurs.

25. RUN-OFF. - Run-off in the Housatonic Watershed is measured by the United States Geological Survey at the twelve gaging stations listed in Table VIII.

(Table VIII on following page)

TABLE VIII

HOUSATONIC RIVER - HYDROLOGIC DATA

River	Station	Period of record	Drainage area in square miles	Discharge in cubic feet per second			Mean annual precipi-tation in inches	Mean annual run-off in inches	Percent of run-off to precipi-tation
				Maximum	Minimum*	Mean*			
Housatonic	Coltsville, Mass.	March 1936 - date	57.1	6,400	1**	123	41	29.23	71
Housatonic	Gt.Barrington,Mass.	May 1913 - date	280	11,520	0**	527	42	25.53	61
Housatonic	Falls Village,Conn.	July 1912 - date	632	19,900	0**	1,038	43	21.93	51
Tenmile	Gaylordsville,Conn.	Dec. 1929 - date	204	12,500	13	270	46	17.95	39
Still	Lanesville, Conn.	Oct. 1931 - date	68.5	4,410	11	114	46	22.60	49
Shepaug	Woodville, Conn.	Oct. 1935 - date	38.0	6,000	0**	88	46	31.41	68
Shepaug	Roxbury, Conn.	Oct. 1930 - date	133	10,500	6.8	231	46	23.60	51
Pomperaug	Southbury, Conn.	June 1932 - date	75.3	7,420	5.2	123	46	22.13	48
Housatonic	Stevenson, Conn	Aug. 1928 - date	1545	69,500	0**	2,338	46	20.50	45
Naugatuck	Thomaston, Conn.	Oct. 1930 - date	71.9	9,970	11	131	47	24.55	52
Leadmine Brook	Thomaston, Conn.	Sept.1930 - date	24.0	2,800	0.4	44	47	24.88	53
Naugatuck	Naugatuck, Conn.	(June 1918-Sept.1924) (Sept.1928-date)	246	18,300	24	413	47	22.71	48

* Minimum and mean discharges computed from records to and including September 1937.
** Regulated.

The maximum, minimum, and mean discharges for these same stations during their periods of record are shown in Table VIII. For the years of record the run-off averages 47 percent of the precipitation. High flows generally occur in March and April, and low flows from July to October. The relation of average monthly run-off to average monthly precipitation is shown in Table VII. Run-off is a function of intensity and duration of the rainfall and the area covered by it, the degree of prior saturation of the ground, the depth and density of snow cover, the temperature of the air and ground, the vegetal covering, the permeability of the soil, and the shape and slope of the watershed. Although notable exceptions have occurred, it is to be expected that the percent of surface run-off from intense storms will be greater than the average annual value of 47 percent regardless of the season of the year.

26. <u>INFLUENCE OF TOPOGRAPHY UPON RUN-OFF.</u> - The shape and topography of the Housatonic Watershed affect the concentration period of flood run-off. Certain factors tend to cause slow accumulation of flood waters and low peak discharges. The extensive natural valley storage along the Housatonic River tends to reduce peak flood discharges on the main stem. The long, narrow shape of the Housatonic Watershed also tends to reduce peak flood discharges, since the flood waters from the tributaries are not concentrated but are fed into the stream throughout its length. The largest tributary, the Naugatuck River, discharges at tidewater and therefore does not contribute to the Housatonic River discharge above flood damage centers. Glacial deposits in the valleys around Pittsfield and below Great Barrington in Massachusetts, and around Derby in Connecticut, provide ground-water storage capacity. There are many lakes and swamp areas providing pondage, besides numerous dams on the main stream and principal tributary. Other factors tend to increase peak

flood discharges. Peak flood discharges on the tributaries, and especially on the Naugatuck River, are comparatively higher, due to the narrow valleys and steep slopes. The Housatonic River is steep throughout its length, except for certain flat reaches near Bulls Bridge and Falls Village, Connecticut, and near Lenox Station and Pittsfield, Massachusetts. These flat sections are subject to flooding annually.

27. <u>INFLUENCE OF TIDE UPON PEAK FLOOD STAGES</u>. - The tide has no influence upon peak flood stages except at Shelton and Derby, Connecticut. On the Housatonic River at Shelton, normal high tide affects flood stages up to discharges of 60,000 cubic feet per second. For higher discharges, the effect of normal tides is negligible. Extremely high tides have occurred, and affect stages at higher discharges. The hurricane of September 1938 caused such a tide at a time when the Housatonic River was in flood. A tide of this magnitude increases flood stages in the lower Housatonic River at Shelton for discharges up to 100,000 cubic feet per second. On the Naugatuck River at Derby, normal high tide affects flood stages up to discharges of 18,000 cubic feet per second. Extremely high tides affect flood stages, up to discharges of 30,000 cubic feet per second.

IV. FLOOD DATA

28. HISTORICAL FLOODS AND STORMS. - Prior to 1900, records of past floods on the Housatonic River and its tributaries are meager, being confined to comments as to approximate stages and damages. The flood of October 1869 was one of the greatest. Run-off data for this flood are so meager that it is impossible to determine the peak discharges. Other historic floods of importance occurred in February 1886, March 1888, and July 1897. The records of the United States Geological Survey gaging station near Gaylordsville, Connecticut, from 1901 to 1912, and at Falls Village, Connecticut, from 1913 to date, show that a peak discharge of 10 cubic feet per second per square mile, or greater, occurred 28 times, generally during the spring break-up. The Gaylordsville record shows a peak discharge of 21,000 cubic feet per second, or 30.4 cubic feet per second per square mile, on March 1, 1902. On February 21, 1903, the discharge was recorded as 25.2 cubic feet per second per square mile, and on January 22, 1910, the discharge was 19.9 cubic feet per second per square mile.

a. Flood of November 1927. - The great New England storm of November 1927 caused the third greatest flood on the Housatonic River since 1900. The record at Stevenson Dam indicates a maximum rate of discharge in 1924 and 1925 about one-third greater than 1927, whereas the Bulls Bridge record indicates 3.4 feet of water over the dam in 1927, 3.2 feet in 1925, and 2.9 feet in 1924. The flood of November 1927 is the highest of record at the Naugatuck gage of the United States Geological Survey. However, above and below this gage the profile was exceeded by the floods of March 1936 and September 1938.

b. Flood of March 1936. - The continental storm of March 1936 produced the second greatest flood on the Housatonic River since

1900. The destruction caused by ice was more serious on the Housatonic River than on other rivers in southern New England. Tributaries of the Housatonic River below Falls Village, Connecticut, discharged great quantities of water into the main valley, each of the principal tributaries reaching a peak on March 12. This caused the peak discharge at the Stevenson Dam of the Connecticut Light and Power Company to occur on March 12, while at all other main-river stations, the peak discharge occurred on March 18, 19, or 20. Heavy ice brought down by the tributary streams united with ice on the main river to make huge jams which formed and broke intermittently. Evidence of the effect of the great ice flows was visible in the entire valley below Falls Village.

c. Flood of September 1938. - The maximum flood of record on the Housatonic River Watershed occurred in September 1938, and resulted from an average rainfall of about nine inches over the entire area. With the exception of the Naugatuck River near Naugatuck and the Housatonic River at Stevenson, all previous stages and discharges of record were exceeded. The storm centered northeast of the watershed and was caused by a prolonged low-pressure area over New England, with warm, moist air entering from the south. The same low-pressure area caused the disastrous hurricane of September 21 to veer inland across New England and produce an abnormally high tide along the southern New England Coast. In the lower reaches of the Housatonic River, the flood occurred almost synchronously with the tidal wave.

29. MAXIMUM COMPUTED FLOOD. - The flood of September 1938 was the greatest flood of record in the Housatonic River Watershed, considering it as a whole. At the United States Geological Survey gaging station at Stevenson and at points below on the Housatonic River, the maximum experienced discharge was caused by the flood of March 1936. A greater flood than any of these would occur in the Housatonic Watershed if a storm

equal to some which have occurred in the region should center over the watershed at a time when conditions are favorable to a high run-off. A maximum computed flood in the Housatonic Watershed has been computed as follows:

a. The rainfall volume used equals the maximum total rainfall which occurred during the storm of September 1938 on an area equal to the drainage area involved. This storm is the maximum storm of record in New England.

b. It was assumed that the entire rainfall occurred in 48 hours and that it was uniformly distributed with respect to area over the watershed.

c. The rainfall distribution with respect to time was assumed to be proportional to that determined by the United States Weather Bureau in a recent study of New England rainfall intensities.

d. An infiltration rate of 0.05 inch per hour was assumed.

e. Unit hydrographs were used in all cases in computing the flood hydrographs at the index stations.

The resulting run-off volume of the maximum computed flood at the points shown in Table IX varies from 11.3 to 14.3 inches, which is equivalent to a run-off of approximately 85 percent. The duration of the flood run-off varies from 5 to 10 days. At the United States Geological Survey gaging station at Stevenson the maximum computed flood has a peak discharge of 150,000 cubic feet per second, which is 2.16 times the maximum recorded discharge of March 1936. The volume, stage, discharge, and probable frequency of the March 1936, the September 1938, and the maximum computed flood at the index stations in the Housatonic Watershed are given in Table IX.

(Table IX on following page)

TABLE IX

HOUSATONIC RIVER - COMPARATIVE FLOOD MAGNITUDES

FLOODS OF MARCH 1936 AND SEPTEMBER 1938 AND MAXIMUM COMPUTED FLOOD

River	Station	Drainage area in square miles	Run-off volume in inches			Stage in feet			Discharge in cubic feet per second			Probable frequency of occurrence in years	
			Mar. 1936*	Sept. 1938	Max. comp.	Mar. 1936	Sept. 1938	Max. comp.	Mar. 1936	Sept. 1938	Max. comp.	Mar. 1936	Sept. 1938
Housatonic	Coltsville, Mass.	57.1	5.16**	4.13	14.00	10.14	10.80	14.4	6,000	6,400	20,000	20	24
Housatonic	Gt.Barrington,Mass.	280.	4.16**	4.29	13.17	10.60	11.72	18.6	8,990	11,520	37,000	21	55
Housatonic	Falls Village, Conn.	632.	3.93**	4.26	12.47	17.41	20.7	42.0	14,500	19,900	66,800	20	56
Tenmile	Gaylordsville, Conn.	204.	3.74	3.99	13.36	11.61	12.77	23.2	10,200	12,500	43,500	43	105
Still	Lanesville, Conn.	68.5	2.55	3.94	13.93	10.58	10.88	28.9	3,930	4,410	14,700	27	41
Shepaug	Woodville, Conn.	38.0	4.91	7.17	-	-	-	-	4,070	6,000	-	-	-
Shepaug	Roxbury, Conn.	133.	3.55	4.74	13.61	10.77	12.8	22.8	7,480	10,500	40,200	8	23
Pomperaug	Southbury, Conn.	75.3	3.23	2.77	13.89	14.13	16.00	35.2	5,990	7,420	33,000	9	22
Housatonic	Stevenson, Conn.	1545.	3.24	3.14	11.32	23.5	21.5	36.9	69,500	59,500	150,000	119	58
Naugatuck	Thomaston, Conn.	71.9	3.91	5.28	13.90	9.37	11.89	22.8	6,590	9,970	29,700	8	58
Leadmine Brook	Thomaston, Conn.	24.0	4.21	3.86	14.34	10.43	11.14	29.0	2,470	3,050	13,000	7	20
Naugatuck	Naugatuck, Conn.	246.	2.95	3.46	13.21	11.96	12.40	30.6	14,800	17,000	83,300	17	31

* Volume under first peak only.
** Volume under second peak only.

V. FLOOD LOSSES

30. GENERAL. - The Housatonic Watershed has sustained damage from local and general floods at various times. Previous to the recent major floods of November 1927, March 1936, and September 1938, damaging floods were reported in 1869, 1886, 1888, 1897, 1902, and 1903. Records of the damage caused by these earlier floods are not available, although it is known that the flood of 1886 took seven lives in the vicinity of Lee, Massachusetts, where a dam was washed out. The flood of 1869 washed out a large section of the Shelton Dam, which was then under construction, and caused other important damages. Damage in the flood of November 1927 totaled approximately $90,000, with major losses occurring to temporary construction plants at Waterbury and Rocky River and to a highway bridge at Beacon Falls, Connecticut. Losses from the recent major floods of March 1936 and September 1938 have been thoroughly investigated and are described in the paragraphs that follow. Losses of record, which were classified as direct, indirect, and depreciation losses, form the basis for computation of average annual losses and average annual benefits to be derived from flood control measures. These benefits form the principal economic justification for flood protection.

31. FLOOD LOSSES OF RECORD.

a. Losses of March 1936. - The flood of 1936 caused damage throughout the entire watershed. Total direct losses amounted to $1,096,000. Stages ranged from one to three feet below those of 1938, although in many localities ice jams resulted in increased stages and damages.

b. Losses of September 1938. - The flood of 1938 reached stages which equalled or exceeded past floods in most localities. Direct losses totaled $2,309,000. There was one life lost by drowning, and two persons died from heart attacks during the flood period. Damage was particularly severe on the upper Housatonic River and its tributaries in Massachusetts, where major damage occurred at Pittsfield, Lee, Great Barrington, and New Marlborough. Approximately 36 bridges were wrecked, and all main highway and railroad travel was interrupted for several weeks. The Housatonic River in Connecticut is not highly developed except at New Milford and in the vicinity of Derby, and, with the exception of these localities, experienced only minor damage. On the Naugatuck River the large manufacturing centers of Torrington, Waterbury, Naugatuck, and Ansonia experienced $271,400 damage, and any further increase in flood stage would have resulted in greatly increased losses.

c. Summary. - Direct losses of the floods of 1936 and 1938 are summarized in Table X. Higher flood stages would cause damages to increase at a much more rapid rate, particularly on the Naugatuck River.

(Table X on following page)

TABLE X

DIRECT FLOOD LOSSES - FLOODS OF 1936 AND 1938

HOUSATONIC RIVER WATERSHED

River basin	State	Flood damage	
		March 1936	September 1938
Housatonic	Mass. & Conn.	$ 794,000	$ 1,548,000
Naugatuck	Conn.	151,000	313,000
Williams	Mass.	21,000	56,000
Blackberry	Conn. & Mass.	20,000	194,000
Tenmile	N. Y. & Conn.	9,000	18,000
Still	Conn.	27,000	106,000
Shepaug	Conn.	64,000	63,000
Pomperaug	Conn.	10,000	11,000
Totals		1,096,000	2,309,000

32. AVERAGE ANNUAL FLOOD LOSSES. -

a. Annual direct losses were determined from flood losses of record allocated to "damage zones" or reaches below proposed reservoirs, and reduced for non-recurring losses. The relation between damage and flood stage or discharge was determined from detailed field investigation and combined with the discharge-frequency relation, from stream flow records, to determine the damage-frequency relationship and average annual damage. Appendix B describes the method in further detail. Table XI summarizes recurring direct losses and average annual losses by damage zones.

b. Annual indirect losses were computed as a percentage of the direct losses, as determined from detailed studies in typical areas by methods of sampling and rational analysis. The percentages

TABLE XI

FLOOD LOSSES BY DAMAGE ZONES

HOUSATONIC RIVER WATERSHED

Damage zone	River	Recurring direct losses		Existing depreciation of real estate from floods of 1936 and 1938**	Average annual losses			
		September 1938 stage	Maximum flood stage*		Direct	Indirect	Deprecia-tion**	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1a	Housatonic	$ 44,500	$ 239,300	$ 0	$ 9,800	$ 5,200	$ 0	$15,000
1b	Housatonic	(1) 39,400	500,000	77,000	8,400	6,000	2,700	17,100
2	Housatonic West Branch	30,000	216,500	0	3,000	1,900	0	4,900
3	Williams	14,200	84,000	0	900	700	0	1,600
4	Housatonic	131,100	1,066,100	0	27,500	23,400	0	50,900
5	Housatonic	56,500	882,200	0	12,700	9,500	0	22,200
6	Blackberry	39,700	142,000	0	2,100	1,600	0	3,700
7	Housatonic	43,800	522,000	0	6,400	5,400	0	11,800
8	Tenmile	14,900	56,500	0	900	400	0	1,300
9	Still	106,000	1,346,000	0	18,600	17,300	0	35,900
10	Housatonic	77,600	570,000	9,000	9,400	8,900	300	18,600
11	Shepaug	58,800	354,000	0	8,700	5,900	0	14,600
12	Pomperaug	9,700	120,000	0	3,400	3,200	0	6,600
13	Housatonic	(2)147,200	968,000	0	10,600	10,300	0	20,900
14a	Naugatuck	37,000	388,000	0	13,500	9,200	0	22,700
14b	Naugatuck	26,000	812,000	0	9,900	10,900	0	20,800
14e	Naugatuck	23,000	216,000	0	2,800	2,200	0	5,000
14f	Naugatuck	10,900	315,000	0	3,300	3,300	0	6,600
15	Naugatuck	195,700	13,200,000	22,000	171,100	148,800	800	320,700
16	Housatonic	Tidewater	---	0	0	0	0	0
	Totals	1,106,000	21,997,600	108,000	323,000	274,100	3,800	600,900

* Stage of flood having a 0.1 percent chance of occurrence.

** Exclusive of direct and indirect losses. Column (8) computed from column (5) at 3.5 percent annually.

(1) Improvements at Van Sickler Dam reduce the loss corresponding to 1938 peak discharge to $30,000.

(2) 1938 crest stage was increased by hurricane wave. Recurring loss corresponding to 1938 peak discharge equals $40,000.

for the individual reaches varied from 100, for industrial areas, to 42, for rural areas. Indirect losses, which include losses of business and wages, costs of relief, and similar losses, both within and without the flood area, are more fully described in appendix B.

c. Depreciation losses, which result from decreases in the value and utility of property beyond that chargeable to direct and indirect losses, are important only in relatively small local areas. The depreciation losses which resulted from the recent floods of 1936 and 1938 totaled $108,000 to real estate having a normal value prior to 1936 of approximately $720,000. Total real estate subject to flooding within damage zones has a value of approximately $86,913,000, while the grand total of real estate and machinery, stock, and other property is estimated at approximately $187,261,000.

33. FLOOD PROTECTION BENEFITS. - The determinable benefits from flood control are derived from reduction of direct and indirect losses and from the increases in property value that result from the assurance of protection. Annual direct benefits were computed as the difference in losses between present or natural conditions and conditions as modified by proposed protective works. The modified losses were computed by combining the discharge-loss and frequency relations as described in paragraph 8 of appendix B, except that the modified frequency curve is used in place of the natural frequency. Benefits accruing to levees or channel improvement were computed from the losses remaining after the selected plan of reservoirs. Annual indirect benefits were computed from direct benefits by application of the percentage determined for each damage zone as described in paragraph 32b. Restoration benefits are based upon recovery of depreciation losses by restoring real estate values to the normal level prevailing prior to 1936. The benefits were computed from the recoverable losses of paragraph 32c in proportion to

the value of the real estate receiving complete protection. Enhancement benefits from potential increases in the value of unimproved land are possible in many localities. Development of many desirable industrial and residential sites adjacent to thriving industrial centers and growing residential areas has been hindered by floods. Any complete protection for these areas would result in development and increases above the normal land value. Benefits accruing to the proposed plan of protection are summarized in paragraph 42 a. They are discussed in greater detail in paragraph 12 of appendix B. Population in the Housatonic Watershed has increased approximately 89 percent since 1900. Since 1938, new industrial buildings valued at close to $900,000 and a number of dwellings have been constructed within the flood area. The further normal development of the flood plain will result in an increase in the direct and indirect losses prevented, which will amount to at least 15 percent at the middle of the assumed 50-year life of the protective works. This increase was estimated from projection of present trends of population and valuation in the principal cities and towns of the watershed, making allowance for decline in the birth rate and immigration, and various changes in economic and other conditions. Other benefits will result from the assurance of protection against a great flood. Floods far exceeding that of 1938 may be expected. Such greater floods would cause serious loss of life and property by overflowing the highly developed areas of Waterbury, Ansonia, and several other cities, and would result in important decreases in the value of property now valued at approximately $170,000,000.

VI. IMPROVEMENT DESIRED

34. PUBLIC HEARINGS.

a. A public hearing was held at Great Barrington, Massachusetts, on July 21, 1936, in connection with the review report submitted on October 1, 1936. As a result of the hearing it appeared that:

(1) Most interest was shown by representatives of Massachusetts, including Pittsfield, Hinsdale, Dalton, Lee, Stockbridge, Great Barrington, and Sheffield.

(2) Conservation in connection with flood control is desirable in order to increase the flow in the river during dry seasons for the benefit of manufacturing plants, and to reduce the degree of pollution.

(3) Considerable interest in the flood control question was developed, and a willingness to cooperate in a Federal project to the extent required by the Flood Control Act of 1936 was expressed in general terms.

b. Another public hearing was held at Waterbury, Connecticut, on July 25, 1939, in connection with this report. Approximately 75 people attended the hearing, representing most of the affected areas and industries in both Connecticut and Massachusetts. Various State and railroad officials were also present. A complete record of the hearing is attached as an inclosure to this report. As a result of this hearing it appeared that:

(1) Disastrous floods which have occurred in the valley have affected the development of the

watershed.

(2) The need and desire for flood control are urgent.

(3) Conservation storage for pollution abatement and maintenance of minimum required flows was considered desirable.

35. MEASURES ADVOCATED BY LOCAL INTERESTS. - The flood control measures suggested by local interests include reservoirs in the headwaters; local protective works at Pittsfield, Lee, Stockbridge, and Great Barrington, Massachusetts, and at New Milford, Shelton, Derby, Ansonia, Waterbury, and Torrington, Connecticut; enlarging bridge openings; general channel improvements; and debris clearance for the entire watershed.

36. SANITATION. - Along the main river and its tributaries in the northern and western portions of the basin, pollution abatement measures are necessary to insure clean streams suitable for the full recreational development of the region. This involves complete treatment of municipal sewage and purification of noxious trade wastes. In recent years several communities, including Pittsfield, Danbury, and Torrington, have installed efficient sewage-disposal works. Present industrial requirements permit a lesser degree of purification of the heavily polluted Naugatuck River. This stream, according to Connecticut authorities, is the most contaminated waterway in the State. Heavy population concentrations combined with extensive industrialization have resulted in nuisance conditions which are both aesthetically objectionable and at times menacing to public health in the Naugatuck Valley. Except for cities along the lower Naugatuck River, nearly all population concentrations are served by sewage-disposal plants. Most of these furnish complete treatment. The trade waste problem is the serious one along the Naugatuck River, but relatively minor elsewhere in the watershed. Since

the main river is an interstate stream, complete pollution control must depend upon cooperation between Massachusetts and Connecticut. The pollution situation and suggested measures for abatement are more fully covered in appendix E.

37. CONSERVATION. - In the development of a system of flood control reservoirs it would be desirable, if economically feasible, to develop the sites under consideration for the conservation of water for power, recreation, processing, and other incidental purposes, in addition to flood control. All sites were studied to determine the feasibility of providing conservation storage in addition to that provided for flood control.

38. NAVIGATION. - There is no necessity at the present time for improvements for navigation on tributaries of the Housatonic River, or on the Housatonic River itself above Otter Rock, which is located three miles above the Shelton Dam. Navigation on the Housatonic River below Otter Rock is beyond the scope of this report. House Document No. 246, Seventy-second Congress, first session, gives the latest recommendations for improvements for navigation on the Housatonic River and outlines existing and completed navigation projects.

39. WILD LIFE. - There are numerous lakes and ponds in the Housatonic Watershed, and there is no special need for further improvements in conjunction with the proposed flood control works to provide benefits to wild life. No measures for this purpose are proposed.

VII. PLAN OF IMPROVEMENT

40. GENERAL. - Four general methods of flood control have been considered for the Housatonic River. They are (1) control of existing reservoirs, (2) additional storage and new reservoirs, (3) channel improvements and levees, and (4) diversion of flood flows.

41. OPERATION OF EXISTING RESERVOIRS. - In the upper part of the Housatonic and Naugatuck Watersheds there are several small storage reservoirs. They are so located in the headwaters that a degree of flood protection could be derived from their operation solely for flood control. These reservoirs must be kept full, however, especially preceding periods of low run-off, to insure an adequate supply of water to the mills which own and operate them, and which already have a deficiency of water for normal use during dry periods. To be used effectively for flood control the reservoirs would have to be kept empty in anticipation of floods, and would therefore be valueless for the purpose for which they are now used. During past floods the surcharge storage above spillway crest at these ponds has somewhat modified flood discharges downstream. The flood records have not been corrected for this surcharge storage effect. Consequently the operation of the conservation reservoirs solely for flood control would provide a lesser degree of flood protection than an equivalent amount of new storage. For the foregoing reasons, control of the existing reservoirs for flood reduction would not be feasible. The ponds of run-of-river plants, such as Bulls Bridge and Falls Village, provide little storage, and the effect of the use of their storage capacities for flood control would be negligible. Increasing the height of the dams of these ponds would be impracticable because of the high cost in proportion to the slight gain in storage. As explained in paragraph 17c, the 41 square miles of drainage area of the Rocky River are completely controlled. It would be impossible to obtain any appreciable flood control storage on

Zoar Lake by providing additional height for Stevenson Dam since raising the crest 10 feet would provide for only 0.14 inch of run-off from 1504 square miles of net drainage area.

42. <u>ADDITIONAL STORAGE</u>. - A system of reservoirs to store flood waters in the upper reaches during critical floods would be the most beneficial method for flood control for the watershed as a whole. An investigation was made to locate all possible dam sites. Most of these were eliminated by preliminary economic studies. Five dam sites were considered worthy of further study, namely, Thomaston, Connecticut, and Hinsdale, Dalton, Lenox Station, and Egremont, Massachusetts. These reservoirs are so located as to furnish as high a degree of protection as possible to downstream damage zones. The most economical reservoir capacity for the Thomaston Reservoir was determined as that capacity for which the greatest ratio of annual benefits to annual charges is obtained. For Hinsdale, Dalton, and Egremont Reservoirs, a minimum storage capacity, equivalent to six inches of run-off from the drainage area above each reservoir, was considered necessary to provide an effective degree of protection for the downstream damage zones. Excessive flowage damages which would result from the use of a larger reservoir limit the capacity at the Lenox Station site to three inches of run-off. A description of each of the sites follows:

<u>a</u>. <u>Thomaston</u>. - The Thomaston dam site is located on the Naugatuck River, 1.1 miles north of Thomaston, Connecticut. The dam will be constructed of rolled earth and rock fill to a maximum height of 136 feet, with a side-channel spillway, having a crest 486.0 feet above mean sea level and 290 feet long, located in rock on the right bank. The dam will be of sufficient height to accommodate a maximum surcharge of 15 feet, with an additional five feet of freeboard. The spillway channel will return to the present channel of the Naugatuck River 325 feet below the toe of the dam. The outlet conduit will be a tunnel of horseshoe section 790 feet long and 15 feet in diameter,

located in rock in the right bank and controlled by three Broome-type gates, each six feet by twelve feet. The operating tower will be near the right abutment. Access to the tower will be provided by a service bridge. The reservoir will have a capacity of 41,500 acre-feet, equivalent to eight inches of run-off from the drainage area of 97 square miles. With the proposed Thomaston Reservoir filled to spillway crest, an area of 910 acres in the towns of Harwinton, Plymouth, Litchfield, and Thomaston, in Litchfield County, will be occupied. Most of this land is either submarginal or devoted to agricultural uses. Some of the storage capacity is located in the valley of Leadmine Brook. The Waterbury and Winsted Branch of the New York, New Haven and Hartford Railroad is below spillway crest elevation for a length of 5.4 miles, making it necessary to relocate 8.0 miles of single track line. State Highway No. 8, 18 feet wide, will require relocation for a distance of 5.4 miles. The total cost of the dam and reservoir will be $5,151,000, with annual charges of $250,600. The total average annual benefits which will accrue to this reservoir, computed as first in the flood control system, are $282,000. The ratio of average annual benefits to annual costs is 1.12. This reservoir will provide a high degree of protection for the entire Naugatuck River below the dam site.

b. Hinsdale. - The Hinsdale dam site is located on the Housatonic River 0.3 mile above Hinsdale, in Berkshire County, Massachusetts. The dam would be constructed of earth by the rolled-fill method to a maximum height of 36.5 feet. The spillway would be a broad-crested weir located in the right abutment. The crest of the spillway would be 1452.5 feet above mean sea level, and 10 feet below the top of the dam. The reservoir outlet would consist of a gate-controlled conduit in the right abutment. The flood control capacity of the reservoir would be 7700 acre-feet, equivalent to six inches of run-off from the drainage area of 24 square miles. With the reservoir filled to spillway crest, an area of 1100 acres would be inundated, including 3.5 miles of main line of the Boston and Albany Railroad and 3.5 miles of 18-foot bituminous macadam road. This reservoir would provide a high degree of protection to downstream points on the Housatonic River, including Hinsdale, Dalton, and Pittsfield. The total average annual benefits which would acrrue to this reservoir, computed as first in a flood control system, would be $27,200. No estimates have been made of the actual cost of the dam and reservoir. Annual charges would amount to $7600 for land and damages, $51,000 for railroad relocation, $7,200 for highway relocation, making a total of $65,900, exclusive of construction and other costs. The total annual charges would therefore greatly exceed the total annual benefits. Consequently this reservoir is not justified for inclusion in the proposed plan.

c. Dalton. - The Dalton dam site is located on the Housatonic River 0.1 mile above Dalton, in Berkshire County, Massachusetts. The dam would be constructed of earth by the rolled-fill method to a maximum height of 75.5 feet. A saddle spillway would be located in the right abutment. The crest of the spillway would be 1193.5 feet above mean sea level and 10 feet below the top of the dam. The reservoir outlet would consist of a gate-controlled conduit in the right abutment. The flood control capacity of the reservoir would be 16,800 acre-feet, equivalent to six inches of run-off from the drainage area of 52.5 square miles. With the reservoir filled to spillway crest, an area of 660 acres would be inundated, including a number of homes in Dalton and three miles of 18-foot bituminous macadam road. This reservoir would provide a high degree of protection to downstream points in the Housatonic River, including Dalton and Pittsfield. The total average annual benefits which would accrue to this reservoir, computed as first in a flood control system, would be $46,600. No estimates have been made of the actual cost of the dam and reservoir. Annual charges for land and damages would amount to $65,200. It is obvious that the total annual charges would greatly exceed the total annual benefits. Consequently this reservoir is not justified for inclusion in the proposed plan.

d. Lenox Station. - The Lenox Station dam site is located on the Housatonic River at mile 123, nine miles below Pittsfield, in Berkshire County, Massachusetts. The existing development at the site would be replaced by an earth dam constructed by the rolled-fill method to a maximum height of 43.5 feet. A saddle spillway would be located in the left abutment. The crest of the spillway would be 980.5 feet above mean sea level and 10 feet below the top of the dam. The reservoir outlet would consist of a gate-controlled conduit in the left abutment. The flood control capacity of the reservoir is limited by the extensive damage which would be caused in Pittsfield by a higher dam. The capacity would be 27,800 acre-feet, equivalent to three inches of run-off from the drainage area of 174 square miles. A permanent pool would be maintained at elevation 949.0 feet above mean sea level to supply the 11.5 feet of head provided by the existing dam. With the reservoir filled to spillway crest, an area of 1650 acres would be inundated, including a number of homes in Pittsfield, four miles of a branch line of the New York, New Haven and Hartford Railroad, and four miles of 18-foot bituminous macadam road. This reservoir would provide protection to downstream points on the Housatonic River, including Lee, South Lee, Stockbridge, Glendale, Housatonic, and Great Barrington. The total average annual benefits which would accrue to this reservoir, computed as first in a flood control system, would be $43,000. No estimates have been made of the actual cost of the dam and reservoir. Annual charges would amount to $65,000 for land and damages, and $25,600 for railroad relocation, making a total of $90,600, exclusive of construction and other costs. It is obvious that the total annual charges would greatly exceed the total annual benefits. Consequently this reservoir is not justified for inclusion in the proposed plan.

e. Egremont. - The Egremont dam site is located on the Green River 2.5 miles above the mouth and 1.5 miles west of Great Barrington.

The dam would be of rolled earth fill with a side-channel spillway on the left abutment. The spillway would be 7400 feet above mean sea level to provide 16,200 acre-feet of capacity, or six inches of run-off from the drainage area of 51 square miles. The dam would have a maximum height of 56 feet, with the top at elevation 7500 feet above mean sea level, to allow for five feet of surcharge on the spillway crest and five feet of additional freeboard. The outlet would be a gate-controlled tunnel in the left abutment. With the reservoir full to spillway crest, an area of 840 acres would be inundated, including a few homes in Egremont Plain and 2.5 miles of 18-foot bituminous macadam highway. This reservoir would provide protection to downstream points on the Housatonic River, including Sheffield, Massachusetts, and Falls Village and New Milford, Connecticut. The total average annual benefits which would accrue to this reservoir, computed as first in a flood control system, would be $11,000. No complete estimate of the actual cost of the dam and reservoir has been made. The annual charges would be $7700 for land and damages, and $11,700 for highways, making a total of $19,400, exclusive of construction and other costs. It is therefore obvious that the total annual charges would greatly exceed the total annual benefits. Consequently this reservoir is not justified for inclusion in the proposed plan.

Local Protection

43. LOCALITIES STUDIED. - Extensive studies have been made to determine the feasibility of providing individual protection to a number of local areas which have suffered appreciable losses in past floods. These areas are listed in Table XII on the following page.

TABLE XII

LOCALITIES INVESTIGATED FOR INDIVIDUAL PROTECTION

HOUSATONIC RIVER WATERSHED

No.	Location	Area investigated
1	Hinsdale, Mass.	Above Lynholm Company dam.
2	Dalton, Mass.	Pioneer Mill - Crane Company.
3	Pittsfield, Mass.	Plan I - from above Lakewood to Van Sickler Dam.
4	Pittsfield, Mass.	Plan II - from Lakewood to Van Sickler Dam.
5	Pittsfield, Mass.	Plan III - from Lakewood to Van Sickler Dam.
6	Pittsfield, Mass.	West Branch Housatonic River - Bel Air Street to Boylston Street.
7	Lee, Mass.	Columbia Mill - Smith Paper Company.
8	Lee, Mass.	Eagle Mill - Smith Paper Company.
9	Lee, Mass.	Below Laurel Street bridge.
10	Lee, Mass.	Hurlbut Paper Company.
11	Stockbridge, Mass.	East Main Street section.
12	Stockbridge, Mass.	Stockbridge Golf Club, right bank.
13	Stockbridge, Mass.	Stockbridge Golf Club, left bank.
14	Stockbridge, Mass.	Glendale Dam.
15	Great Barrington, Mass.	Monument Mills, headwater protection.
16	Great Barrington, Mass.	Monument Mills, tailwater protection.
17	Great Barrington, Mass.	Rising Paper Company.
18	Great Barrington, Mass.	Housatonic Agricultural Society fair grounds.
19	New Milford, Conn.	Left bank, above highway bridge.
20	New Milford, Conn.	Robertson Bleachery and Dye Works.
21	New Milford, Conn.	Right bank, below highway bridge.
22	Shelton, Conn.	Right bank, above and below Shelton bridge.
23	Derby, Conn.	Plan I - Shelton bridge to Philgas Company plant - partial protection.
24	Derby, Conn.	Plan II - Shelton bridge to Philgas Company plant - complete protection.
25	Derby, Conn.	Plan III - Shelton bridge to Division Street bridge - complete protection.
26	Derby, Conn.	Plan IV - Shelton bridge to Bridge Street bridge - complete protection.
27	Derby, Conn.	Plan V - Shelton Canal Company dam to Cemetery Avenue - partial protection.
28	New Canaan, Conn.	Right bank - Blackberry River.
29	Washington Depot, Conn.	Right bank.
30	Washington Depot, Conn.	Left bank.
31	Danbury, Conn.	Patch Street to Cross Street.
32	Torrington, Conn.	East Branch Naugatuck River - from Winsted Road to East Main Street bridge.
33	Torrington, Conn.	Main Branch Naugatuck River - Union Hardware Company.
34	Torrington, Conn.	Main Branch Naugatuck River - American Brass Company dam to Wolcott Avenue.
35	Torrington, Conn.	Main Branch Naugatuck River - junction with East Branch to American Brass Company dam.
36	Torrington, Conn.	Naugatuck River below East Albert Street bridge, right bank.
37	Ansonia, Conn.	Left bank, above and below Bridge Street.

Protective measures in the form of levees, walls, or channel improvements, either singly or in combination, have been considered in determining the most economical type of protection. Of the 37 sites investigated, protection was found to be economically justified at only two locations; at the Columbia Mill in Lee, Massachusetts, and at the Monument Mills in Great Barrington, Massachusetts. Although no plan of channel improvement for Pittsfield could be economically justified, results of the investigation are included in this report. At all other places the annual cost of protective works, based upon preliminary studies, greatly exceeded the annual benefits to be derived, and the projects were not further considered. Summaries of these preliminary studies are presented in appendix C.

Channel Improvements

44. PITTSFIELD, MASSACHUSETTS. - The most serious damage zone in Pittsfield is that extending along the Housatonic River for 9500 feet above Van Sickler Dam. The drainage area at the dam is 71 square miles. After the September 1938 flood two flood gates, 6 feet by 8 feet, were installed in the left abutment of the dam, through the cooperation of the City of Pittsfield, the County of Berkshire, and the State of Massachusetts. The September 1938 flood produced a peak discharge of 3400 cubic feet per second over the dam and through the two existing 4-foot by 5-foot gates, and reached a height of 5.4 feet above the crest of the dam. The same head on the dam with the new gates in operation would pass a discharge of 4800 cubic feet per second. This represents a 40 percent increase in capacity. There are several sewer crossings and restricted bridge openings above the dam, which, together with the natural meanders and small cross section of the channel, tend to retard run-off and to decrease materially the effectiveness of the flood gates. The Hinsdale or the Dalton Reservoir would afford a high degree of protection to this area, but, as has been shown in Paragraph 42, the costs of these reservoirs are greater than the benefits which would accrue to them. A residential area of about 100 homes, situated at the upstream end of the river stretch and known as "Lakewood", is subject to frequent flooding. Other properties nearby which have been damaged include the extensive plant of the General Electric Company, a city electric plant, several small industries, and some residential and commercial property in the vicinity of Silver Lake. The flood of September 1938 caused shallow flooding of this area and damage to house cellars, plant basements, and boiler rooms. The losses totaled $39,000. The flood of March 1936 caused damage of approximately the same amount. The General Electric Company sustained direct losses of approximately $4000 and indirect losses of $2000 as a result of the September 1938 flood.

Since the September 1938 flood the power station has been modernized at an expense of several hundred thousand dollars. An additional $7000 has been spent on flood protection measures consisting mainly of waterproofing walls and bulkheading windows, particularly in the boiler house. The City of Pittsfield has completed considerable channel improvement work under a Works Progress Administration project on the West Branch of the Housatonic River. A channel improvement project on the Housatonic River above Van Sickler Dam is contemplated, at a cost to the State of $75,000. The City of Pittsfield has budgeted an additional $40,000 to cover the cost of raising two bridges and eliminating other obstructions to the flow. The plan of improvement being contemplated is similar to Plan III, below, the main difference being that, in the local plan, riprap will be placed only at bridge abutments, and walls will be placed at certain locations to prevent overbank flooding. The flood losses are further discussed in appendix B. A complete description of the Pittsfield channel improvement, Plan III, below, appears in Paragraphs 15 to 22, inclusive, of appendix D. Three plans of protection were considered for this section of the Housatonic River.

a. Plan I. - This plan would afford complete protection against a computed design discharge of 10,500 cubic feet per second. The channel would be straightened and excavated to a section having a uniform capacity. Where necessary, levees and walls would be built. Adequate drains would be placed behind the levees to provide for natural drainage. Riprap would be placed about the abutments of three bridges, and two bridges would be raised. The total annual cost is estimated to be $76,200, with annual benefits amounting to $20,700. The ratio of benefits to costs would be 0.27, and the plan of improvement is not economically justified.

b. Plan II. - This plan would afford protection against a flood of 6000 cubic feet per second. The channel alinement and cross section would be the same as in Plan I, the levees and walls would not be so high, and the cost of providing for the natural drainage would be less because the levees would not extend around Goodrich Pond. Riprap would be placed as in Plan I. One bridge would be moved and one bridge would be raised. The total annual cost is estimated to be $48,600, with annual benefits amounting to $15,000. The ratio of benefits to costs would be 0.31, and the plan of improvement is not economically justified.

c. Plan III. - This plan would protect against a flood of 3400 cubic feet per second, which is equal to the largest flood of record. The channel alinement and cross section are shown on Plates Nos. 3 and 4 of appendix D. The improvement would shorten the stretch of river above Van Sickler Dam from 11,500 feet to 8500 feet, and provide a uniform section with bottom width of 50 feet and 1 on 2 side slopes. No levees would be provided, and only a very short section of concrete wall would be necessary, thereby eliminating the necessity for providing drains for the natural drainage. Riprap would be placed on the side slopes for the entire length of the improvement, and on the bottom near each bridge. The excavated material from the channel would be used to fill in low-lying areas adjacent to the stream. The Longview Terrace footbridge would be moved, raised one foot, and lengthened, and the Lyman Street bridge would be raised one and one-half feet. The grades of trunk sewers at three river crossings would be lowered to allow an unobstructed flow in the proposed channel. The proposed change in channel alinement would necessitate extending and constructing outlets for existing storm-water drains now discharging into the channel. This plan is discussed in detail in Paragraphs 15 to 23, inclusive, of appendix D. The total average annual cost would be $20,460, with annual benefits amounting to $13,400. The ratio of benefits to costs would be 0.65, and the plan of improvement is not economically justified.

Levees and Walls

45. **LEE, MASSACHUSETTS.** - Damage caused by the September 1938 flood in the town of Lee amounted to $43,700. The most important damage centers have been studied individually. They are the Columbia and Eagle Mills of the Smith Paper Company, the residential section just below the Laurel Street highway bridge, and the Hurlbut Paper Company. Direct losses to these properties in the September 1938 flood amount to $8400. The remaining damage was principally to highways and railroads. Additional damage of $32,200 was reported on Goose Pond Brook and other small streams in the town of Lee. Only a small portion of the loss would be recurring, because of improvements, reconstruction, and protective measures taken by the Massachusetts Department of Public Works. Of the four locations investigated, only the protection at the Columbia Mill was found to be economically justified. The other three locations are discussed in appendix C.

a. **Columbia Mill.** - The Columbia Mill of the Smith Paper Company is located on the Housatonic River at mile 120.75. The straight wood-crib dam has a height of 14 feet and a crest length of 116 feet. The mill is operated by the Smith Paper Company and is fully utilized for the manufacture of cigarette paper, and employs approximately 225 people. The value of buildings, dam, and equipment will approach $1,000,000. A small building is now under construction. The flood of September 1938 washed out the right abutment of the dam and flooded over the left abutment into the mill. Losses totaled $2300 direct and $6200 indirect.

(1) **Plan of Protection.** - Protection of the mill from headwater damage could be obtained by the construction of a concrete wall along the left bank of the pond, extending from high ground at the railroad track to the left abutment

of the dam. A stop-log structure would be necessary at the railroad track, and new head-gates would be installed at the dam. The wall would be approximately 6 feet high above the present ground surface, or 5.5 feet above the September 1938 high water. The length would be approximately 570 feet. An auxiliary spillway would be constructed in the right abutment of the dam. There is no damage from tailwater at this mill.

(2) Cost and benefits. - The total estimated cost of this plan of improvement is $138,000, with annual charges of $6900. The total average annual benefits which would accrue to this improvement would be $28,800. The ratio of annual benefits to annual costs is 4.2.

46. GREAT BARRINGTON, MASSACHUSETTS. - The September 1938 flood caused damages amounting to $83,400 in the town of Great Barrington, Massachusetts. Individual protection was investigated for the Monument Mills, the Rising Paper Company, and the fair grounds of the Housatonic Agricultural Society. These areas sustained damage of $34,700. Additional damage of $10,000 occurred to the village of Great Barrington, to the Berkshire Coated Paper Company, and to the hydroelectric station of the Southern Berkshire Power and Electric Company. Losses to the hydroelectric station are not recurring because of improvements which protect the plant against a stage slightly above the September 1938 flood height. The Berkshire Coated Paper Company plant has been idle until recently, when it resumed operation after being reconditioned and repaired. In the village of Great Barrington the Great Barrington Manufacturing Company was flooded in September 1938 but sustained damage of only $800. Other losses in the town of Great Barrington were to agricultural properties, highways, and railroads. The property of the Rising Paper Company is now being protected by the State of Massachusetts against a flood discharge as high as that of September 1938. The protec-

tion consists of wood piling driven into the ground, with rock fill placed on both sides. The river has been dredged, widened, and straightened. No estimate can be made of the channel capacity without a survey, but it will probably be great enough to pass the flood of record without serious damage. Protection to the fair grounds could be provided by the construction of an earth levee approximately 4000 feet long and 15 to 18 feet high. It would be necessary to straighten the river, excavate it to a uniform channel, and provide for natural drainage. The only individual protection found to be justified in the town of Great Barrington was at the Monument Mills, against headwater damage. The results of the studies at the Rising Paper Company and the fair grounds of the Housatonic Agricultural Society are presented in appendix C.

a. Monument Mills. - The Monument Mills are a large group of buildings operating as a textile mill, employing approximately 250 people at the present time, although normal employment would be twice that number. The land and buildings have a normal value in excess of $1,000,000, and equipment and stock make the total value much greater. The flood of September 1938 caused total direct losses of $23,800. Of this amount, $3000 is recurring in the tailwater, and $2800 is recurring in the headwater above the dam. Approximately one-third of the plant was closed for five days, resulting in indirect losses of $21,300. Damage from headwater was kept to a small amount by sandbagging and blocking of windows. A larger flood would flow over the headgates and the right abutment of the dam, into the second floor of the mill, and cause great damage to stock and machinery on the first and second floors of the main plant.

(1) Plan of improvement. - Protection against the headwater damage at the Monument Mills in Great Barrington could be provided by the construction of a concrete wall 115 feet long and 10.6 feet high

above the crest of the dam, or 3.7 feet higher than the high water of September 1938. Stop-log structures would be built at the railroad and at Highway No. 183. New headgates and gate structures would be included in the improvement.

(2) Cost and benefits. - The total estimated cost of this plan of improvement is $71,000, with annual charges of $4,000. The total average annual benefit which would accrue to this improvement would be $13,000. The ratio of annual benefits to annual costs is 3.2.

47. WATERBURY, CONNECTICUT. - The direct flood losses for the September 1938 flood amounted to $86,100 in the town of Waterbury. The reach of the Naugatuck River from the South Leonard Street bridge to above the West Main Street bridge was studied in detail, and a survey record map of the entire reach was made. The September 1938 direct losses in this reach amounted to $40,200. The Thomaston Reservoir would eliminate most of these losses in the future. Since that reservoir, with a flood control capacity of eight inches, was found to be justified, only that section of Waterbury between the Mad River and 1600 feet above Bank Street was given further study. A channel improvement was investigated for this section, in which the dam of the American Brass Company would be removed and the channel would be excavated to a uniform grade and cross section from the Mad River to the spur track railroad bridge of the American Brass Company, and from the Bank Street bridge to a point 1600 feet upstream from the Bank Street Bridge. With Thomaston Reservoir built to a capacity of eight inches, the average annual cost of this local improvement would greatly exceed the average annual benefit. Further studies proved that it would not be advantageous to build the Thomaston Reservoir with a smaller capacity than eight inches in combination with this channel improvement. With the Thomaston Reservoir built, no project can be justified in this

short reach, where the flood damage is highly concentrated and the cost of the improvement moderate. The Thomaston Reservoir would likewise afford the most economical protection for the remaining section of this highly industrialized valley.

Power and Conservation

48. POWER.

a. Power development at the Thomaston site. - The feasibility of developing hydroelectric power at the Thomaston site, in addition to providing flood control storage, has been investigated. The cost of providing added storage capacity was estimated, and the cost of a power plant and electrical equipment, conservatively estimated, was added. In order to provide a basis favorable to the development of power, the installed capacity was computed from the minimum regulated flow and a load factor of 25 percent. The annual value of the power has been estimated, upon the basis of unit values of $12.50 per kilowatt of installed capacity and 1.5 mills per kilowatt-hour of output. Pertinent data for the Thomaston Reservoir, constructed as a dual-purpose project with power installed at the site, are given in Table XIII.

TABLE XIII

POWER DEVELOPMENT AT THOMASTON RESERVOIR

Drainage area	97	square miles
Reservoir capacity for flood control	41,500	acre-feet
Reservoir capacity for power	10,400	acre-feet
Power storage draw-down	5,700	acre-feet
Average power head	59	feet
Minimum regulated flow	61	cubic feet per second
Installed capacity	980	kilowatts
Annual value of peaking capacity plus output at the site	$19,700	
Annual value of storage to downstream plants	$ 2,200	
Total annual value	$21,900	
Annual cost of storage plus power installation	$37,300	
Ratio of value to cost	0.6	

b. Power storage for downstream benefits. - There are five water-power developments on the Naugatuck River, downstream from the proposed Thomaston Reservoir, all of which are industrial plants. They are not highly developed, and thus could not make the maximum use of increased flows without added installation. In order to show maximum benefits to power storage at the Thomaston Reservoir, liberal assumptions regarding the value and usableness of increased low flows were made. A value of five mills per kilowatt-hour was assigned to the coal-saving or energy value of the increased low flows at the downstream industrial plants, and it was assumed that the total storage available would be used once a year at 100 percent utilization. Pertinent data covering additional storage for the benefit of downstream power at the Thomaston Reservoir are given in Table XIV.

TABLE XIV

POWER CONSERVATION STORAGE AT THOMASTON RESERVOIR

Storage capacity for downstream power benefit	10,400 acre-feet
Increase of minimum flow	41 cubic feet per second
Downstream developed head - industrial	93 feet
Downstream developed head - utility	0 feet
Increased peaking capacity at utility plants	---
Increased yearly output	788,000 kilowatt-hours
Annual value of increased peaking capacity and output	$ 3,900
Annual cost of power storage	$21,500
Ratio of value to cost	0.2

The value of power storage, even under the liberal assumptions used, would therefore be much less than the cost of providing it, and consequently it is not justified.

49. CONSERVATION. - An amendment to Section 5 of the Act entitled "An Act authorizing the construction of certain public works on rivers and harbors for flood control, and for other purposes," approved June 22, 1936, authorizes the Secretary of War "To receive from States and political subdivisions thereof, such funds as may be contributed by

them to be expended in connection with funds appropriated by the United States for any authorized flood control work * * * * * * and the plans for any reservoir project may, in the discretion of the Secretary of War, on recommendation of the Chief of Engineers, be modified to provide additional storage capacity for domestic water supply or other conservation storage, on condition that the cost of such increased storage capacity is contributed by local agencies." In accordance with this Act, local interests were consulted to ascertain their desire for conservation storage for abatement of pollution, recreation, or other uses. A responsible State official has stated that there would seem to be little doubt that conservation storage would be of value to both the municipalities and the industries. The State desired to make no request at this time, but stated that the desire for conservation storage among the local interests in the valley would be investigated, and a report would be submitted if the reservoir were approved.

VIII. DISCUSSION AND CONCLUSIONS

50. GENERAL. - The topographic features of the main stem of the Housatonic River are not such as to produce high peak flood discharges as compared with other watersheds of different features. These flood reducing effects do not exist on the Naugatuck tributary.

a. Housatonic River. - Peak flood discharges have not been high in the past due to the peculiar topographic and geologic features of the river basin, and these same features will reduce future peak flood discharges. Flood losses from past floods have been very slight except at Pittsfield, Massachusetts, principally because the past floods have not been great and because the valley is not intensely developed. Four reservoir sites in the headwaters of the Housatonic River were investigated, but no single reservoir or combination of reservoirs could be economically justified. Local protection at thirty-seven locations was investigated, but at only two private mills was it found to be economically justified. The problem at each of these mills pertains to the company affected and is not considered a Federal one, inasmuch as the flood damage is due to initial construction inadequate to protect against a flood of reasonable expectancy, and as all the property that would be protected is owned by one private company. Protection at these places is recommended for private improvement. The City of Pittsfield has improved flood run-off conditions along the West Branch of the Housatonic River for discharges equal to the highest of record. Municipal funds have been allocated for general improvement along the main stream. These projects will materially reduce future flood damages in Pittsfield.

b. Naugatuck River. - The peak flood discharges of past floods on the Naugatuck River have been comparatively higher than on the Housatonic River and have caused considerable damage. There are no peculiar topographic or geologic features which tend to reduce peak flood discharges. From hydrologic studies it is apparent that it would be possible for this river to experience peak flood discharges which would greatly exceed any that have occurred in the past. Flood losses from past floods have been serious, but any greater flood would cause excessive damage since the entire valley is highly industrialized. In many places through the industrial areas, the river is walled in by the foundations of the industrial buildings, and past floods have just reached the top of the protective walls. The potential damage of a greater flood is therefore very high. This valley is the brass and copper center of the United States. There are also important rubber and chemical industries located in the valley, and any interruption of these industries would be very serious in time of war. The construction and operation of the Thomaston dam and reservoir will eliminate all serious flood hazards from this valley below the dam site.

51. PROPOSED PLAN OF IMPROVEMENT. - The protection of the Naugatuck Valley from flood damage is a separate problem, since the Naugatuck River enters the Housatonic River at tidewater. It is proposed to protect this valley by the construction of the Thomaston Reservoir.

a. Thomaston Reservoir. - The Thomaston Reservoir, located on the Naugatuck River 1.1 miles above Thomaston, Connecticut, with a capacity of eight inches, would completely control 97 square miles of drainage area, or 57 percent of the drainage area at Waterbury which is the principal damage zone, and 31 percent of the drainage area at the mouth. The Naugatuck Valley is the brass and copper center of the United States, and diversified mill works constitute 80 percent of the industry in the valley. There are also rubber works, dye works, silk mills, textile works, paper mills, and breweries in the valley.

Three floods of nearly the same peak discharge, in eleven years, have caused considerable damage in this valley, and any moderate increase of this discharge would cause a great increase in the flood damage. The Thomaston Reservoir will eliminate this flood hazard on the Naugatuck River, by completely controlling 31 percent, or more, of the drainage area. The March 1936 and the September 1938 direct recurring losses, and the modifying effect that Thomaston Reservoir would have had on these flood losses, are shown in Table XV. The reductions in discharge and stage which the proposed reservoir would effect for floods similar to those of March 1936 and September 1938, and the maximum computed flood, are shown in Table XVI.

(Tables XV and XVI on following page)

TABLE XV

REDUCTION IN DIRECT RECURRING LOSSES ON THE NAUGATUCK RIVER EFFECTED BY THE PROPOSED THOMASTON RESERVOIR

Zone	Index Station	March 1936 Natural	March 1936 After Modification by Proposed Project	March 1936 Reduction	September 1938 Natural	September 1938 After Modification by Proposed Project	September 1938 Reduction	Flood of 0.1% Chance of Occurrence Natural	Flood of 0.1% Chance of Occurrence After Modification by Proposed Project	Flood of 0.1% Chance of Occurrence Reduction
14F	Thomaston	$ 0	$ 0	$ 0	$ 10,900	$ 0	$ 10,900	$ 315,000	$ 0	$ 315,000
15	Naugatuck	72,000	2,300	69,700	109,600	6,900	102,700	7,050,000	1,630,000	5,420,000
15	Waterbury	42,000	200	41,800	86,100	300	85,800	6,150,000	970,000	5,180,000
	Total	114,000	2,500	111,500	206,600	7,200	199,400	13,515,000	2,600,000	10,915,000

TABLE XVI

REDUCTION IN DISCHARGE AND STAGE ON THE NAUGATUCK RIVER EFFECTED BY THE PROPOSED THOMASTON RESERVOIR

FLOODS OF MARCH 1936 AND SEPTEMBER 1938, AND THE MAXIMUM COMPUTED FLOOD

Station	Drainage Area (Sq. Mi.)	March 1936 Discharge (Cubic Feet Per Second) Natural	March 1936 Discharge Modified	March 1936 Discharge Reduced	March 1936 Stage (Feet) Natural	March 1936 Stage Modified	March 1936 Stage Reduced	September 1938 Discharge (Cubic Feet Per Second) Natural	September 1938 Discharge Modified	September 1938 Discharge Reduced	September 1938 Stage (Feet) Natural	September 1938 Stage Modified	September 1938 Stage Reduced	Maximum Computed Flood Discharge (Cubic Feet Per Second) Natural	Maximum Computed Flood Discharge Modified	Maximum Computed Flood Discharge Reduced	Maximum Computed Flood Stage (Feet) Natural	Maximum Computed Flood Stage Modified	Maximum Computed Flood Stage Reduced
Thomaston Dam Site	97	9,000	0	9,000	-	-	-	12,500	0	12,500	-	-	-	37,300	15,000	22,300	-	-	-
Waterbury	179	12,000	4,900	7,100	258.1	253.0	5.1	15,400	5,100	10,300	260.3	253.0	6.7	58,700	27,600	31,100	-	-	-
Naugatuck	246	14,800	8,500	6,300	11.96	8.81	3.15	17,000	7,600	9,400	12.40	7.80	4.60	83,300	59,900	23,400	30.6	25.3	5.3
Ansonia	312	18,400	12,400	6,000	28.7	26.5	2.2	18,200	9,300	8,900	28.6	25.1	3.5	92,800	70,000	22,800	-	-	-

TABLE XV

REDUCTION IN DIRECT RECURRING LOSSES ON THE NAUGATUCK RIVER
EFFECTED BY THE PROPOSED THOMASTON RESERVOIR

Zone	Index Station	March 1936: Natural	March 1936: After Modification by Proposed Project	March 1936: Reduction	September 1938: Natural	September 1938: After Modification by Proposed Project	September 1938: Reduction	1000-Year Flood: Natural	1000-Year Flood: After Modification by Proposed Project	1000-Year Flood: Reduction
14F	Thomaston	$ 0	$ 0	$ 0	$ 10,900	$ 0	$ 10,900	$ 315,000	$ 0	$ 315,000
15	Naugatuck	72,000	2,300	69,700	109,600	6,900	102,700	7,050,000	1,630,000	5,420,000
15	Waterbury	42,000	200	41,800	86,100	300	85,800	6,150,000	970,000	5,180,000
	TOTAL	114,000	2,500	111,500	206,600	7,200	199,400	13,515,000	2,600,000	10,915,000

TABLE XVI

REDUCTION IN DISCHARGE AND STAGE ON THE NAUGATUCK RIVER
EFFECTED BY THE PROPOSED THOMASTON RESERVOIR

FLOODS OF MARCH 1936 AND SEPTEMBER 1938, AND THE MAXIMUM COMPUTED FLOOD

Station	Drainage Area (Sq. Mi.)	March 1936						September 1938						Maximum Computed Flood					
		Discharge (Cubic Feet Per Second)			Stage (Feet)			Discharge (Cubic Feet Per Second)			Stage (Feet)			Discharge (Cubic Feet Per Second)			Stage (Feet)		
		Natural	Modified	Reduced	Natural	Modified	Reduced	Natural	Modified	Reduced	Natural	Modified	Reduced	Natural	Modified	Reduced	Natural	Modified	Reduced
Thomaston Dam Site	97	9,000	0	9,000	-	-	-	12,500	0	12,500	-	-	-	37,300	15,000	22,300	-	-	-
Waterbury	179	12,000	4,900	7,100	258.1	253.0	5.1	15,400	5,100	10,300	260.3	253.0	6.7	58,700	27,600	31,100	-	-	-
Naugatuck	246	14,800	8,500	6,300	11.96	8.81	3.15	17,000	7,600	9,400	12.40	7.80	4.60	83,300	59,900	23,400	30.6	25.3	5.3
Ansonia	312	18,400	12,400	6,000	28.7	26.5	2.2	18,200	9,300	8,900	28.6	25.1	3.5	92,800	70,000	22,800	-	-	-

52. COSTS AND BENEFITS. - The total cost of the Thomaston Reservoir is estimated at $5,151,000. The total cost will be borne by the United States and is estimated at $250,600 annually. The average annual benefits have been computed to be $282,000. The ratio of total annual benefits to total annual costs is 1.12 for the Thomaston Reservoir. This ratio is conservative, since benefits not easily evaluated, including loss of life and protection against interruption in the manufacture of products essential to national defense, have not been considered.

53. UNEVALUATED BENEFITS. - Losses previously discussed and used to compute the average annual benefits have been those easily assigned a monetary value. There are additional benefits which have not been evaluated. No estimate has been made of the increase in annual direct losses which will result from the normal growth and development that may be reasonably anticipated even if flood protection is not provided. Protective works will provide greater benefits from the restoration of depreciated values than were computed under Paragraph 32 c, if the works are constructed at an early date before depreciation becomes permanent and less easily recovered. No enhancement benefits have been attributed to the proposed Thomaston Reservoir. Benefits will result from the increase in population and the building developments made feasible by protection of the flooded areas. Benefits not easily assigned a monetary value will result from the elimination of the serious adverse effects upon the lives and security of the people and the communities concerned, including potential loss of life, mental and physical strain, hardship, inconvenience, and impairment of public health. In the Housatonic Watershed those elements of flood experience and apprehension, which may not be easily evaluated, are of outstanding importance in view of the recent experience of three great floods in the last fourteen years.

The elements of uncertainty influence the utilization, desirability, and future growth of the area. Their elimination forms an additional justification for the protective works. No monetary value can be assigned to the benefit derived from the elimination of the serious natural flood hazard to industries in the Naugatuck Valley which manufacture products essential to national defense in wartimes.

54. ATTITUDE OF LOCAL INTERESTS. - Considerable desire for flood protection throughout the Housatonic Watershed has been demonstrated, especially in the populous centers where the heaviest damages occur. Local interests have shown a willingness to cooperate in any flood protection program.

55. CONSERVATION AND POWER. - Additional storage for the development of power at the Thomaston Reservoir site is not justified. Conservation for the abatement of pollution damages and for recreation can be provided at this site without causing excessive upstream damages.

56. POLLUTION. - There is a major pollution problem on the Naugatuck River. Elimination of this condition can be accomplished only by the construction and operation of treatment facilities serving the population centers and industrial zones. The Federal Government is not economically justified in assuming the cost of the additional storage at the Thomaston Reservoir solely for pollution abatement. The pollution problem is analyzed in detail in appendix E. Abatement measures are suggested for the consideration of State and other local authorities.

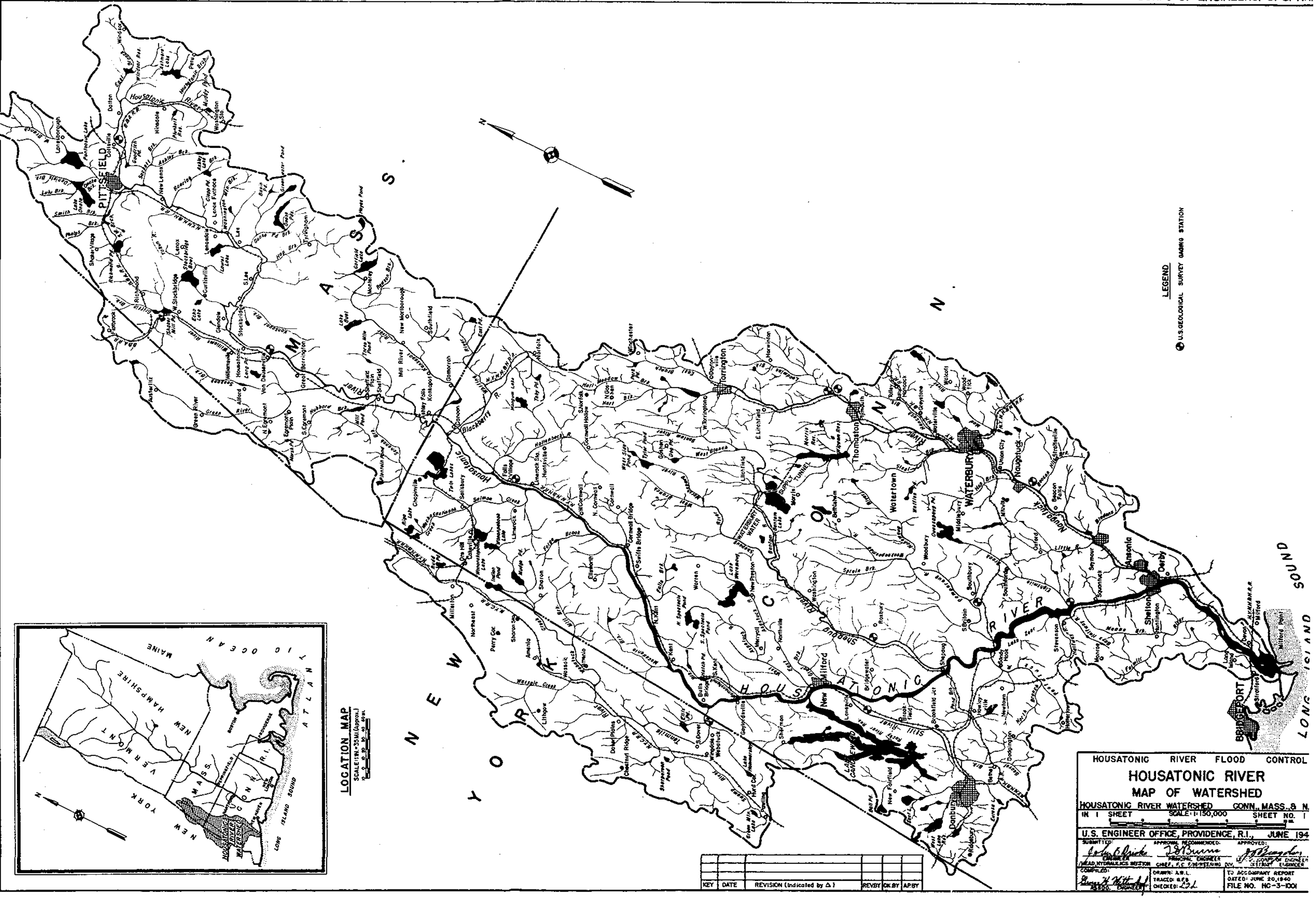
57. ENFORCEMENT OF STATE AND LOCAL REGULATIONS. - Strict enforcement is recommended of existing State and local regulations governing the construction, operation, and inspection of dams, bridges, and other structures, or the filling in of land, the driving of piles, and the dumping of refuse and debris in the stream to prevent encroachment on the flood channel. The States of Connecticut, Massachusetts, and New York have such legislation in effect at the present time.

IX. RECOMMENDATIONS

58. RECOMMENDATIONS. - It is recommended that a flood control reservoir be built on the Naugatuck River about 1.1 miles above Thomaston, Connecticut, with a flood control capacity equivalent to eight inches of run-off from the drainage area of 97 square miles. It is further recommended that this reservoir be built in the immediate future, since uninterrupted operation of the brass and other metal manufacturing facilities of this valley are vitally important to the national defense. The estimated total cost of the reservoir is $5,151,000. It is further recommended that, if requested by local interests, the flood control capacity of the Thomaston Reservoir be increased to provide conservation in the amount desired by them, provided that the increased cost of the enlarged reservoir, in excess of the cost for the flood control reservoir, be contributed by local interests prior to construction. If authorized, allotment for this work should be made in one sum to secure economical prosecution of the work.

J. S. Bragdon,
Lieut. Col., Corps of Engineers,
District Engineer.

Inclosures:
Record of hearing (6 copies).


LEGEND
U.S. GEOLOGICAL SURVEY GAGING STATION
LOCATION MAP
MASS.
CONN.
NEW YORK
CONNECTICUT
HOUSATONIC RIVER
PITTSFIELD
WATERBURY
TORRINGTON
BRIDGEPORT
DANBURY
LONG ISLAND SOUND
HOUSATONIC RIVER FLOOD CONTROL
HOUSATONIC RIVER
MAP OF WATERSHED
HOUSATONIC RIVER WATERSHED CONN., MASS., & N.
IN 1 SHEET SCALE: 1:150,000 SHEET NO. 1
U.S. ENGINEER OFFICE, PROVIDENCE, R.I., JUNE 194
TO ACCOMPANY REPORT DATED: JUNE 20, 1940
FILE NO. HC-3-1001
KEY DATE REVISION (Indicated by Δ) REV.BY CK.BY AP.BY

REPORT ON SURVEY

OF THE HOUSATONIC RIVER AND TRIBUTARIES

FOR FLOOD CONTROL

APPENDICES

APPENDIX A - PRINCIPAL EXISTING DAMS AND WATER-POWER DEVELOPMENTS

APPENDIX B - FLOOD LOSSES

APPENDIX C - LOCAL PROTECTION WORKS

APPENDIX D - DETAILS OF DESIGN AND ESTIMATES OF COST

APPENDIX E - POLLUTION

UNITED STATES ENGINEER OFFICE

PROVIDENCE, RHODE ISLAND

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APPENDIX A - PRINCIPAL EXISTING DAMS AND WATER-POWER DEVELOPMENTS

APPENDIX A - PRINCIPAL EXISTING

DAMS AND WATER-POWER DEVELOPMENTS

1. PRINCIPAL EXISTING DAMS AND WATER-POWER DEVELOPMENTS. - Pertinent data concerning the principal existing dams and water-power developments in the Housatonic Basin are shown in the following table. Their locations are given on Plate No. 1, appendix A.

(Table I on pages 2 - 4 inclusive)

TABLE I – APPENDIX A

PRINCIPAL EXISTING DAMS AND WATER-POWER DEVELOPMENTS IN THE HOUSATONIC BASIN

SERIAL NUMBER	LOCATION	MILES ABOVE MOUTH	DRAINAGE AREA IN SQUARE MILES	OWNER	PRODUCT MANUFACTURED	SPILLWAY LENGTH FEET	HEAD IN FEET	ELEVATION – FEET ABOVE MEAN SEA LEVEL: FLASHBOARDS	ELEVATION – FEET ABOVE MEAN SEA LEVEL: CREST	INSTALLED CAPACITY HORSEPOWER	REMARKS
		HOUSATONIC RIVER – CONNECTICUT									
1	Shelton	13.5	1,575	Connecticut Light and Power Co. Shelton Canal Co.	(See remarks)	675	19.5	25.2	23.7	2,300	Arched stone and plank dam; locks; head is sold to: 5 plants in Shelton on 4500-foot canal; 2 plants in Derby on 2100-foot canal. Manufacturing electricity, pins, buttons, photographic devices, etc.
2	Stevenson	19.3	1,543	Connecticut Light and Power Co. Stevenson Plant	Electricity	546	71.6	101.7	98.3	36,000	Straight concrete dam.
3	New Milford	42.3	1,123	Robertson Bleachery and Dye Works	Cloth finish	190	10.0		196.6	400	Arched natural stone dam; between island and left bank. 90 feet of straight stone and concrete weir dam 1.7 feet above main dam.
4	Bulls Bridge	52.9	784	Connecticut Light and Power Co. Bulls Bridge Plant.	Electricity	195	109.1		354.7	11,000	Arched rock and concrete dam; 8400-foot canal; 1600-foot forebay; between island and riverbank, 133 feet of concrete weir dam 3.0 feet below main dam with 3.0-foot flashboards.
5	Falls Village	76.2	631	Connecticut Power Co. Falls Village Plant.	Electricity	320	99.0	633.1	631.6	14,000	Concrete dam with 6-inch sill bolted to concrete, 1600-foot canal.
		HOUSATONIC RIVER – MASSACHUSETTS						PERMANENT			
6	Great Barrington	102.0	333	Southern Berkshire Power and Electric Co.	Electricity	94	11.8	680.8	680.3	620	Straight concrete dam.
7	Housatonic	105.8	277	Rising Paper Co.	Paper	131	22.0	718.3	716.6	1,300	Straight log and stone dam.
8	Housatonic	107.1	276	Monument Mills, Number 1 Mill.	Cotton goods	124	18.7		747.9	125	Straight rock ballasted crib dam.
9	Glendale	107.9	275	Monument Mills, Furnace Plant.	(Inoperative)	158	21.0		768.7	750	Straight rock ballasted crib dam.
10	Glendale	109.4	272	Monument Mills, Glendale Plant.	Electricity	220	41.0	812.8	810.8	1,500	Straight concrete dam; 1500-foot canal.
11	South Lee	114.6	232	Hurlbut Paper Co.	Paper	100E	18.5		839.0	500	Arched stone and concrete dam; 500-foot canal; old log and earth dam upstream with 10-inch flashboards during summer.

E = ESTIMATED.

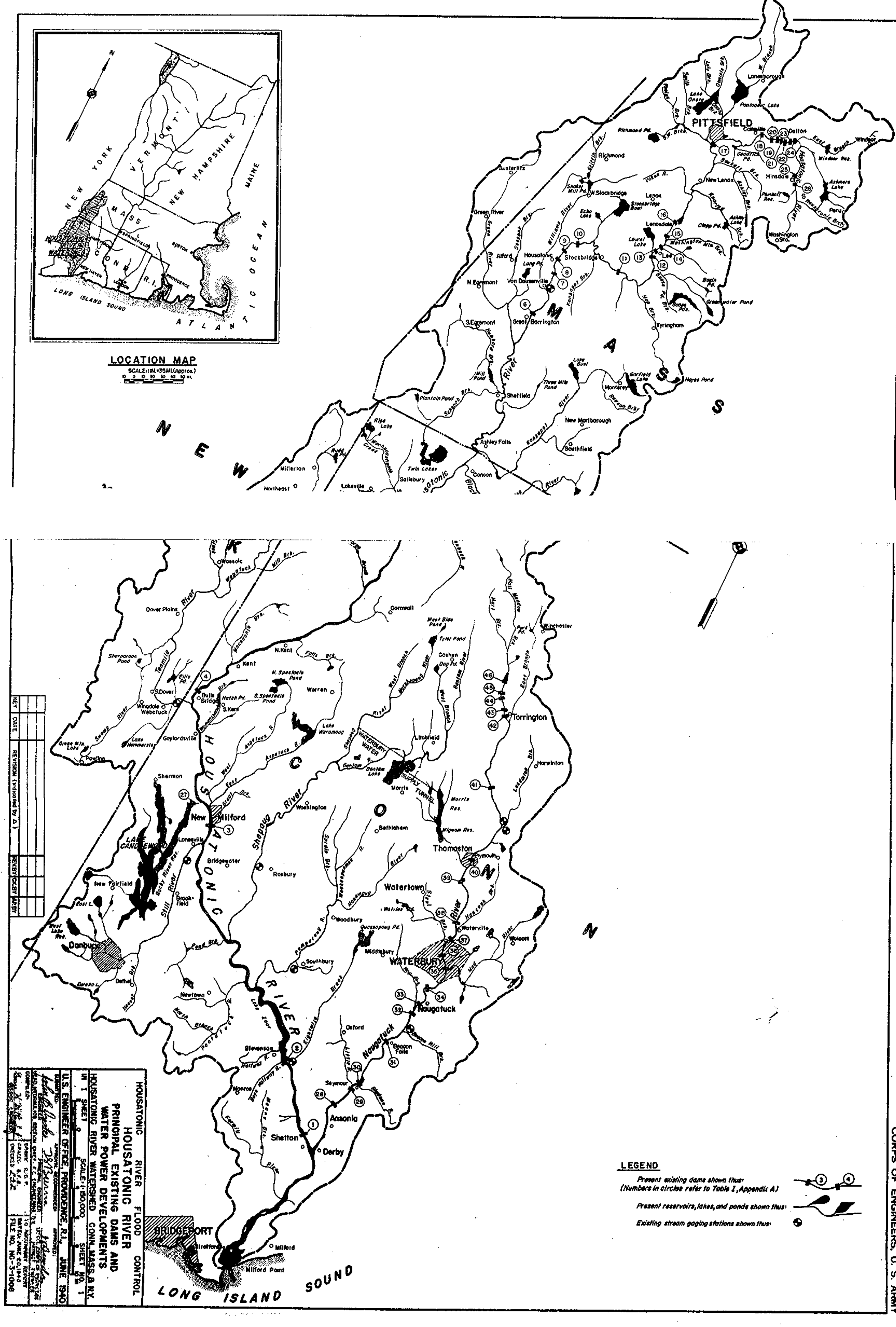
TABLE I - APPENDIX A (CONTINUED)

SERIAL NUMBER	LOCATION	MILES ABOVE MOUTH	DRAINAGE AREA IN SQUARE MILES	OWNER	PRODUCT MANUFACTURED	SPILLWAY LENGTH FEET	HEAD IN FEET	ELEVATION - FEET ABOVE MEAN SEA LEVEL: FLASHBOARDS	ELEVATION - FEET ABOVE MEAN SEA LEVEL: CREST	INSTALLED CAPACITY HORSEPOWER	REMARKS
	HOUSATONIC RIVER - MASSACHUSETTS (CONTINUED)										
12	LEE	119.8	196		(INOPERATIVE)	150E	9.0		880.5	220	1200-FOOT CANAL.
13	LEE	120.2	184	SMITH PAPER CO., EAGLE MILL.	PAPER	116	10.0		891.8	310	STRAIGHT WOOD CRIB DAM.
14	LEE	120.8	183	SMITH PAPER CO., COLUMBIA MILL.	PAPER	116	14.0		907.5	510	STRAIGHT WOOD CRIB DAM.
15	LENOXDALE	122.0	178	SMITH PAPER CO., HYDRO-ELECTRIC PLANT.	ELECTRICITY	118	24.0		936.0	1,700	STRAIGHT WOOD CRIB DAM; 1400-FOOT PIPE LINE, 11-FOOT DIAMETER.
16	LENOX STATION	123.1	174	SMITH PAPER CO., VALLEY MILL.	PAPER	180	11.5		949.0	280	WOOD CRIB DAM; 1300-FOOT CANAL.
17	PITTSFIELD	132.0	71	DALE BROTHERS	LAUNDRY	74	14.5	975.6	974.1	125	STRAIGHT CONCRETE DAM (VAN SICKLER DAM).
18	DALTON	136.7	57	CRANE AND CO., GOVERNMENT MILL.	PAPER	100E	13.5		1,010.5	200	ARCHED STONE DAM.
19	DALTON	137.5	55	CRANE AND CO., BAY STATE MILL.	PAPER	100E	19.0		1,030.0	320	ARCHED STONE DAM.
20	DALTON	137.7	55	CRANE AND CO., PIONEER MILL.	PAPER	100E	14.5		1,044.2	200	ARCHED STONE DAM.
21	DALTON	138.1	54	CRANE AND CO., BERKSHIRE MILL.	PAPER	90E	26.5		1,071.0	340 OR LESS	STRAIGHT CONCRETE DAM; 1000-FOOT CANAL.
22	DALTON	138.5	53	SAWYER REAGAN CO.	WOOLEN GOODS	80E	22.0		1,094.0	125	ARCHED WOOD DAM.
23	DALTON	138.7	52	BYRON WESTON CO.	PAPER	90E	23.0		1,117.0	340	ARCHED STONE DAM.
24	DALTON	138.8	52	BYRON WESTON CO.	PAPER	90E	19.0		1,136.0	300	ARCHED STONE DAM.
25	HINSDALE	142.7	28	CRANE AND CO., DALTON POWER CO.	ELECTRICITY	60E	163.5		1,337.5	670	STRAIGHT STONE AND WOOD DAM.
26	HINSDALE	143.5	24	LYNHOLM CO.		50E	12.5		1,422.4	(NONE)	STRAIGHT STONE AND WOOD DAM.
	ROCKY RIVER - CONNECTICUT										
27	NEW MILFORD	1.0	40	CONNECTICUT LIGHT AND POWER CO., ROCKY RIVER PLANT.	ELECTRICITY		230.0		428.1	32,000	
	NAUGATUCK RIVER - CONNECTICUT										
28	ANSONIA	4.1	302	AMERICAN BRASS CO.	BRASS AND COPPER PRODUCTS	245	35.3	54.0	52.0	1,000	CONCRETE SPILLWAY; CANAL 2.23 MILES
29	SEYMOUR	6.0	295	NEW HAVEN COPPER CO., H.P. AND E.DAY, INC., TINQUE MANUFACTURING CO.	COPPER, FOUNTAIN PENS, MOHAIR, AND VELVET.		16.7	74.6	73.6	680	STONE MASONRY DAM; WATER ALSO USED FOR PROCESSING; A 75-HORSEPOWER INSTALLATION IS IDLE.
30	SEYMOUR	6.5	283	RIMMON WATER CO. SEYMOUR MANUFACTURING CO.	NICKEL, SILVER	150	18.6		93.5	400	EARTH FILL, TIMBER-FACED DAM; INSTALLATION IDLE.

E = ESTIMATED.

TABLE I - APPENDIX A (CONTINUED)

SERIAL NUMBER	LOCATION	MILES ABOVE MOUTH	DRAINAGE AREA IN SQUARE MILES	OWNER	PRODUCT MANUFACTURED	SPILLWAY LENGTH FEET	HEAD IN FEET	ELEVATION - FEET ABOVE MEAN SEA LEVEL: FLASHBOARDS	ELEVATION - FEET ABOVE MEAN SEA LEVEL: CREST	INSTALLED CAPACITY HORSEPOWER	REMARKS
				NAUGATUCK RIVER - CONNECTICUT (CONTINUED)							
31	BEACON FALLS	10.7	260	BEACON FALLS RUBBER SHOE CO.		392	26.2	143.0	142.0		STONE AND CONCRETE DAM; WATER NOT USED; U.S. RUBBER CO. SUBSIDIARY; CANAL 0.8 MILE LONG.
32	NAUGATUCK	13.4	245	NAUGATUCK CHEMICAL CO.	RECLAIMED RUBBER	160	2.0		171.6		TIMBER DAM; WATER USED FOR PROCESSING; U.S. RUBBER CO. SUBSIDIARY.
33	NAUGATUCK	14.0	240	U. S. RUBBER CO.	RUBBER FOOTWEAR	215	11.5		186.4		TIMBER AND CONCRETE DAM; WATER USED FOR COOLING.
34	PLATTS MILLS	16.2	212	PLATT BROTHERS AND CO.	ZINC	229	15.0		222.3	50	ROCK-FILL TIMBER DAM.
35	WATERBURY	18.4	179	AMERICAN BRASS CO.	BRASS	210	1.5		247.1		TIMBER DAM; WATER USED FOR PROCESSING; DAM BROKEN.
36	WATERBURY	19.2	175	CONNECTICUT LIGHT AND POWER CO.		145	4.0	256.0	252.0		CONCRETE OGEE SPILLWAY; COLLAPSIBLE FLASHBOARDS.
37	WATERBURY	21.0	155	AMERICAN BRASS CO.	NICKEL SILVER, BRASS	140	4.4		268.2		ROCK-FILL TIMBER DAM; CANAL 1 MILE LONG; WATER USED FOR PROCESSING.
38	WATERVILLE	23.0	135	CHASE BRASS AND COPPER CO.	BRASS AND COPPER	115	6.5	287.3	285.8		CONCRETE OGEE SPILLWAY; WATER USED FOR PROCESSING AND COOLING.
39	REYNOLDS BRIDGE	27.5	108	ORIS BAKELITE CO.	PLASTIC MOULDING	90	7.0		343.4	25	ROCK-FILL PLANKED DAM.
40	THOMASTON	29.0	99	PLUME AND ATWOOD MANUFACTURING CO.	BRASS	125	3.4		363.2		ROCK-FILL PLANKED DAM; WATER USED FOR PROCESSING AND FIRE PROTECTION.
41	CAMPVILLE STATION	33.2	68	N. W. ROWLEY	LUMBER	100	16.0		435.5	35	ROCK-FILL PLANKED DAM; CANAL 0.25 MILE LONG.
42	TORRINGTON	39.7	32	HOTCHKISS BROTHERS CO.	MILLWORK	110	12.0		589.5		ROCK-FILL PLANKED DAM; WATER USED TO FEED BOILER.
43	TORRINGTON	40.0	32	AMERICAN BRASS CO.	BRASS	91	12.5		600.6		CONCRETE SPILLWAY; WATER USED FOR PROCESSING; CANAL 0.25 MILE LONG.
44	TORRINGTON	41.0	31	UNION HARDWARE CO.	HARDWARE	65	4.2				ROCK-FILL PLANKED DAM; WATER USED FOR PROCESSING; CANAL 0.4 MI. LONG.
45	TORRINGTON	41.4	25	HENRY AUST	POWER	50	12.0			12	CONCRETE DAM; CANAL 500 FEET LONG.
46	TORRINGTON	42.4	24	AMERICAN BRASS CO.		200	27.0				CONCRETE DAM; WATER STORED TO AUGMENT LOW FLOWS.



WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

APPENDIX A PLATE NO. 1

APPENDIX B - FLOOD LOSSES

APPENDIX B - FLOOD LOSSES

1. GENERAL. - The floods of March 1936 and September 1938 caused important damages which are described in the following paragraphs. Damage has also been reported for a great many other floods, but complete records are not available except for the flood of November 1927, which caused direct losses totaling approximately $90,000. The losses of March 1936 and September 1938 have been thoroughly investigated and were used as a basis for the computation of average annual losses. Annual benefits, derived from average annual losses prevented, form the principal economic justification for flood protection.

2. LOSSES OF MARCH 1936. - The flood of 1936 caused important losses and was exceeded only by the flood of September 1938. Damage was particularly severe along the upper Housatonic and tributaries, where ice jams increased river stages and damages. Major bridges went out at North Kent, Swifts Bridge, and Cornwall, Connecticut, and others were destroyed on the Aspetuck River and elsewhere. No important dam failures occurred, although there was a washout at Plunkett Reservoir in Hinsdale, Massachusetts. Twenty-five houses or cottages were swept away in various parts of the watershed but no lives were lost. Direct losses of 1936 total $1,096,000, as summarized in Table I.

3. LOSSES OF SEPTEMBER 1938. - The flood of 1938 was the maximum of record in the Housatonic Watershed, although it was exceeded by earlier floods in some localities. The flood caused direct losses of $2,309,000. There was one life lost by drowning, and two persons died of heart attack during the flood period. Approximately 1400 homes and 350 commercial establishments were flooded. Over 90 industrial plants and several power stations were damaged or forced to shut down. About 4500 acres of farm land were inundated, but crops had generally been harvested and the agricultural damage was not great. Losses are summarized

TABLE I - APPENDIX B

DIRECT FLOOD LOSSES - FLOOD OF MARCH 1936

HOUSATONIC RIVER WATERSHED

BY TRIBUTARIES

TRIBUTARY	STATE	URBAN*	AGRICULTURAL	INDUSTRIAL**	HIGHWAY	RAILROAD	TOTAL
HOUSATONIC	MASS. & CONN.	$160,000	$ 68,000	$194,000	$346,000	$ 26,000	$ 794,000
NAUGATUCK	CONN.	53,000	1,000	52,000	33,000	12,000	151,000
WILLIAMS	MASS. & N. Y.	1,000	1,000	3,000	15,000	1,000	21,000
BLACKBERRY	MASS. & CONN.	3,000	2,000	0	15,000	0	20,000
TENMILE	CONN. & N. Y.	4,000	3,000	0	2,000	0	9,000
STILL	CONN.	15,000	1,000	7,000	3,000	1,000	27,000
SHEPAUG	CONN.	37,000	1,000	7,000	14,000	5,000	64,000
POMPERAUG	CONN.	0	2,000	1,000	6,000	1,000	10,000
TOTALS		273,000	79,000	264,000	434,000	46,000	1,096,000

BY STATES

TOTAL	N. Y.	4,000	3,000	1,000	6,000	0	14,000
TOTAL	MASS.	80,000	63,000	77,000	249,000	10,000	479,000
TOTAL	CONN.	189,000	13,000	186,000	179,000	36,000	603,000
GRAND TOTAL		273,000	79,000	264,000	434,000	46,000	1,096,000

* RESIDENTIAL, COMMERCIAL, AND PUBLIC LOSSES.
** INCLUDES UTILITY.

in Table II and discussed by basins in the following paragraphs.

a. Housatonic River. - During the flood of September 1938, the Housatonic River reached stages one to three feet above the 1936 crest stage. Direct losses amounted to $1,248,000 in Massachusetts and $313,000 in Connecticut. In Massachusetts three main highway bridges on the main river were wrecked and numerous bridges on small tributary streams were also destroyed. Although no important dams were washed out, twelve were damaged. The city of Pittsfield sustained direct losses of $148,500 on the Housatonic River and West Branch. In the "Lakewood" section, approximately 130 families were driven from their homes when the area was overflowed to a depth of 2 to 3 feet. The large plant of the General Electric Company, which employs 8000 people, sustained losses in the boiler room and basements. Mills and other property in Lenox, Lee, and Great Barrington, Massachusetts, were damaged. Wide areas in Sheffield were also inundated, but losses were small owing to the fact that there is little development of the flood plain and crops had been harvested within the portion under cultivation. In Connecticut, considerable damage was experienced at New Milford, Derby, and Shelton. At New Milford, a large bleachery and a total of 30 houses and stores were flooded up to 4 feet deep on the first floor, with damage totaling $90,400. Shelton and Derby, which are located near the confluence with the Naugatuck River at the limit of tidewater, sustained total direct losses of $140,900 by basement flooding of the dense industrial and commercial areas along the banks of the river. The property in these two localities has a total value of approximately $17,800,000, so that potential losses are high. Damage is not important in other areas of the Housatonic River in Connecticut, since there are no developed centers and the river valley is generally deep and narrow.

b. Naugatuck River, Connecticut. - On the Naugatuck River the 1938 flood exceeded the floods of 1927 and 1936 by a few inches except

TABLE II - APPENDIX B

DIRECT FLOOD LOSSES - FLOOD OF SEPTEMBER 1938

HOUSATONIC RIVER WATERSHED

BY TRIBUTARIES

TRIBUTARIES	STATE	URBAN*	AGRICUL-TURAL	INDUS-TRIAL**	HIGHWAY	RAILROAD	TOTAL
		$	$	$	$	$	$
HOUSATONIC	MASS. & CONN.	237,000	96,000	268,000	884,000	63,000	1,548,000
NAUGATUCK	CONN.	151,000	0	98,000	58,000	6,000	313,000
WILLIAMS	MASS. & N. Y.	3,000	2,000	4,000	45,000	2,000	56,000
BLACKBERRY	MASS. & CONN.	13,000	5,000	0	176,000	0	194,000
TENMILE	CONN. & N. Y.	5,000	8,000	0	2,000	3,000	18,000
STILL	CONN.	52,000	3,000	46,000	5,000	0	106,000
SHEPAUG	CONN.	37,000	3,000	6,000	12,000	5,000	63,000
POMPERAUG	CONN.	2,000	3,000	1,000	5,000	0	11,000
TOTALS		500,000	120,000	423,000	1,187,000	79,000	2,309,000

BY TOWNS - NEW YORK

TOWN	DAM-AGE ZONE	ASSESSED VALUE 1937-1938	DIRECT FLOOD LOSSES - SEPTEMBER 1938					
			URBAN*	AGRICUL-TURAL	INDUS-TRIAL**	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		$	$	$	$	$	$	$
AMENIA	8	2,001,456	0	3,000	0	300	0	3,300
DOVER	8	1,791,585	4,000	3,700	0	1,000	2,100	10,800
NORTHEAST	8	2,063,186	500	300	0	0	0	800
CANAAN	#	1,075,459	0	0	1,000	9,000	0	10,000
MISCELLANEOUS			500	1,000	0	700	900	3,100
TOTAL FOR NEW YORK		6,931,686	5,000	8,000	1,000	11,000	3,000	28,000

BY TOWNS - CONNECTICUT

TOWN	DAM-AGE ZONE	ASSESSED VALUE 1937-1938	DIRECT FLOOD LOSSES - SEPTEMBER 1938					
			URBAN*	AGRICUL-TURAL	INDUS-TRIAL**	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		$	$	$	$	$	$	$
ANSONIA	15	23,762,076	31,700	0	12,800	5,000	1,500	51,000
BEACON FALLS	15	1,498,727	3,000	0	0	100	0	3,100
BRIDGEWATER	10	816,790	0	0	100	3,000	0	3,100
BROOKFIELD	9	1,396,870	0	500	0	0	0	500
CANAAN	7	1,170,094	0	0	0	1,100	6,000	7,100
CORNWALL	7		1,600	0	0	300	6,000	7,900
CORNWALL	#		0	0	0	7,500	0	7,500
CORNWALL, TOTAL		1,536,101	1,600	0	0	7,800	6,000	15,400
DANBURY	9	44,550,299	51,600	1,200	45,800	5,000	0	103,600
DERBY	13	15,160,092	24,300	0	30,000	4,500	7,000	65,800
HARWINTON	14E	1,131,994	0	0	0	1,100	0	1,100
KENT	7	2,186,793	800	0	300	12,000	5,600	18,700

* RESIDENTIAL, COMMERCIAL, AND PUBLIC LOSSES.
** INCLUDES UTILITY LOSSES.
# IN COLUMN (2) IDENTIFIES LOSSES IN TOWNS OUTSIDE DAMAGE ZONES DESCRIBED IN TABLE III.

TABLE II (CONTINUED) - APPENDIX B

BY TOWNS - CONNECTICUT

TOWN	DAMAGE ZONE	ASSESSED VALUE 1937-1938	DIRECT FLOOD LOSSES - SEPTEMBER 1938					
			URBAN*	AGRICULTURAL	INDUSTRIAL**	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		$	$	$	$	$	$	$
LITCHFIELD	14E		0	0	0	3,000	700	3,700
LITCHFIELD	#		0	0	0	2,000	0	2,000
LITCHFIELD, TOTAL		8,829,113	0	0	0	5,000	700	5,700
MONROE	13	3,125,421	0	0	2,500	0	0	2,500
MORRIS	11	1,861,387	0	0	0	5,000	0	5,000
NAUGATUCK	15	20,758,160	18,900	0	30,200	2,000	0	51,100
NEW MILFORD	9		0	600	0	0	0	600
NEW MILFORD	10		28,400	1,000	44,500	600	0	74,500
NEW MILFORD	#		0	0	0	15,300	0	15,300
NEW MILFORD, TOTAL		10,410,779	28,400	1,600	44,500	15,900	0	90,400
NEWTOWN	13	5,173,990	200	200	0	700	0	1,100
NORFOLK	#	4,625,216	2,500	0	0	7,500	0	10,000
NORTH CANAAN	6		10,300	4,300	0	25,000	0	39,600
NORTH CANAAN	#		0	400	0	0	0	400
NORTH CANAAN, TOTAL		2,176,336	10,300	4,700	0	25,000	0	40,000
OXFORD	13	1,664,980	2,000	0	0	0	0	2,000
ROXBURY	11	2,052,940	0	0	0	2,100	2,700	4,800
SALISBURY	7	6,681,799	1,600	5,200	3,000	1,100	0	10,900
SEYMOUR	15	8,875,300	3,800	0	2,300	100	0	6,200
SHARON	7	3,352,546	8,000	0	0	1,200	0	9,200
SHELTON	13	12,754,556	25,700	0	44,400	1,000	4,000	75,100
SHERMAN	#	2,029,250	0	2,000	0	1,000	0	3,000
SOUTHBURY	12		1,200	500	1,000	2,000	0	4,700
SOUTHBURY	13		200	0	0	300	0	500
SOUTHBURY	#		0	0	0	5,000	0	5,000
SOUTHBURY, TOTAL		2,013,375	1,400	500	1,000	7,300	0	10,200
THOMASTON	14F		0	0	5,900	0	2,000	7,900
THOMASTON	#		0	0	0	3,500	0	3,500
THOMASTON, TOTAL		5,673,508	0	0	5,900	3,500	2,000	11,400
TORRINGTON	14A		33,100	0	1,600	4,100	0	38,800
TORRINGTON	14B		18,100	0	5,500	2,500	0	26,100
TORRINGTON	14E		9,300	0	4,000	5,000	0	18,300
TORRINGTON, TOTAL		84,735,230	60,500	0	11,100	11,600	0	83,200
WARREN	#	1,289,838	0	0	0	2,700	0	2,700
WASHINGTON	11	6,788,697	36,400	2,100	5,900	2,300	2,300	49,000
WATERBURY	15	167,326,316	30,800	0	34,300	20,000	1,000	86,100
WATERTOWN	15C		2,000	0	0	400	500	2,900
WATERTOWN	#		0	0	0	11,000	0	11,000
WATERTOWN, TOTAL		10,783,876	2,000	0	0	11,400	500	13,900
WOODBURY	12	2,767,755	0	2,000	0	3,000	0	5,000
MISCELLANEOUS			1,500	2,000	1,900	1,000	700	7,100
TOTAL FOR CONNECTICUT		465,834,780	347,000	22,000	276,000	170,000	40,000	855,000

* RESIDENTIAL, COMMERCIAL, AND PUBLIC LOSSES.
** INCLUDES UTILITY LOSSES.
\# IN COLUMN (2) IDENTIFIES LOSSES IN TOWNS OUTSIDE DAMAGE ZONES DESCRIBED IN TABLE III.

TABLE II (CONTINUED) - APPENDIX B

BY TOWNS - MASSACHUSETTS

TOWN	DAMAGE ZONE	ASSESSED VALUE 1937-1938	DIRECT FLOOD LOSSES - SEPTEMBER 1938 URBAN*	AGRICULTURAL	INDUSTRIAL**	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		$	$	$	$	$	$	$
ALFORD	#	303,405	0	0	0	15,700	0	15,700
DALTON	1		0	15,000	9,400	2,000	0	26,400
DALTON	#		0	0	0	16,100	0	16,100
DALTON, TOTAL		8,436,518	0	15,000	9,400	18,100	0	42,500
EGREMONT	#	974,871	2,100	0	0	3,000	0	5,100
GREAT BARRINGTON	4		500	0	29,500	0	0	30,000
GREAT BARRINGTON	5		11,600	11,800	11,000	13,900	0	48,300
GREAT BARRINGTON	#		0	0	0	2,100	3,000	5,100
GREAT BARRINGTON, TOTAL		9,414,781	12,100	11,800	40,500	16,000	3,000	83,400
HANCOCK	#	433,935	0	0	0	27,000	0	27,000
HINSDALE	1		5,000	5,000	0	0	1,500	11,500
HINSDALE	#		0	0	0	27,600	0	27,600
HINSDALE, TOTAL		1,012,421	5,000	5,000	0	27,600	1,500	39,100
LANESBOROUGH	2		500	6,000	0	2,000	0	8,500
LANESBOROUGH	#		0	0	0	13,000	0	13,000
LANESBOROUGH, TOTAL		1,255,905	500	6,000	0	15,000	0	21,500
LEE	4		5,300	8,500	7,400	12,500	10,000	43,700
LEE	#		45,100	15,000	63,800	198,000	0	321,900
LEE, TOTAL		5,199,817	50,400	23,500	71,200	210,500	10,000	365,600
LENOX	4		300	2,700	500	1,500	3,500	8,500
LENOX	#		0	0	0	20,900	0	20,900
LENOX, TOTAL		6,712,781	300	2,700	500	22,400	3,500	29,400
MONTEREY	#	864,606	0	0	0	58,000	0	58,000
MOUNT WASHINGTON	#	225,191	0	0	0	17,000	0	17,000
NEW MARLBOROUGH	#	1,399,771	16,300	1,000	0	245,000	0	262,300
PERU	#	312,590	0	0	0	3,000	0	3,000
PITTSFIELD	1A		0	5,000	1,200	18,000	500	24,700
PITTSFIELD	1B		20,500	0	5,300	13,500	0	39,300
PITTSFIELD	2		11,400	1,000	4,100	7,800	0	24,300
PITTSFIELD	4		100	0	0	1,000	0	1,100
PITTSFIELD	#		6,000	9,000	1,500	42,600	0	59,100
PITTSFIELD, TOTAL		64,856,706	38,000	15,000	12,100	82,900	500	148,500
RICHMOND	#	773,723	0	1,000	0	3,400	0	4,400
SHEFFIELD	5		1,100	3,200	0	0	7,000	11,300
SHEFFIELD	#		0	1,000	7,500	7,900	0	16,400
SHEFFIELD, TOTAL		1,516,631	1,100	4,200	7,500	7,900	7,000	27,700

* RESIDENTIAL, COMMERCIAL, AND PUBLIC LOSSES.
** INCLUDES UTILITY LOSSES.
\# IN COLUMN (2) IDENTIFIES LOSSES IN TOWNS OUTSIDE DAMAGE ZONES DESCRIBED IN TABLE III.

TABLE II (CONTINUED) - APPENDIX B

BY TOWNS - MASSACHUSETTS

TOWN	DAMAGE ZONE	ASSESSED VALUE 1937-1938	DIRECT FLOOD LOSSES - SEPTEMBER 1938 URBAN*	AGRICULTURAL	INDUSTRIAL**	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		$	$	$	$	$	$	$
STOCKBRIDGE	4		18,200	0	0	21,800	8,000	48,000
STOCKBRIDGE	#		0	0	0	2,300	0	2,300
STOCKBRIDGE, TOTAL		5,548,116	18,200	0	0	24,100	8,000	50,300
TYRINGHAM	#	500,982	0	2,500	1,300	86,800	0	90,600
WASHINGTON	#	220,773	0	0	0	43,500	0	43,500
WEST STOCKBRIDGE	3		2,800	500	2,500	8,400	1,500	15,700
WEST STOCKBRIDGE	#		0	0	0	23,800	0	23,800
WEST STOCKBRIDGE, TOTAL		1,312,691	2,800	500	2,500	32,200	1,500	39,500
WINDSOR	#	504,895	0	0	0	45,800	0	45,800
MISCELLANEOUS			1,200	1,800	1,000	1,100	1,000	6,100
TOTAL FOR MASSACHUSETTS		111,781,110	148,000	90,000	146,000	1,006,000	36,000	1,426,000
TOTAL FOR CONNECTICUT		465,834,780	347,000	22,000	276,000	170,000	40,000	855,000
TOTAL FOR NEW YORK		6,931,686	5,000	8,000	1,000	11,000	3,000	28,000
GRAND TOTAL		584,547,576	500,000	120,000	423,000	1,187,000	79,000	2,309,000

* RESIDENTIAL, COMMERCIAL, AND PUBLIC LOSSES.
** INCLUDES UTILITY LOSSES.
\# IN COLUMN (2) IDENTIFIES LOSSES IN TOWNS OUTSIDE DAMAGE ZONES DESCRIBED IN TABLE III.

at Naugatuck, where the 1927 flood was one foot higher, and at Torrington, where the 1936 flood was 2-1/2 feet lower. Direct losses on the Naugatuck River totaled $313,000. Near the headwaters, a major portion of the commercial, industrial, and residential areas of Torrington were flooded 2 to 3 feet deep by back-up in constricted areas and overflow of the Naugatuck River and East Branch, resulting in damage of $83,200. Damage of $86,100 occurred at Waterbury, mostly in the vicinity of Bank Street Bridge where both banks of the river were flooded about two feet deep. The city of Waterbury has a menace of severe flooding, for floods of greater magnitude will flood property valued at approximately $41,000,000 and cause damages of several million dollars. At Naugatuck, direct losses of $51,100 were experienced as a result of flooding a residential area of 40 houses, by topping a local levee, and damaging three industrial plants. Beacon Falls and Seymour sustained small losses but were on the verge of great damage. Direct losses in Ansonia totaled $51,000 to heavy metal industries located along the bank of the river and to an extensive commercial area, where basements were flooded. Like the other industrial centers of the Naugatuck River, Ansonia is subject to far greater losses since property valued at approximately $6,800,000 will be damaged by higher floods.

c. Williams River, Massachusetts and New York. - The flood of September 1938 exceeded the crest stage of 1936 by approximately 2-1/2 feet. Direct losses totaled $56,000, of which the major part was to highway and railroad. Two bridges were wrecked and a few dwellings and stores flooded. Two power stations were also damaged.

d. Blackberry River, Massachusetts and Connecticut. - The flood of 1938 caused damage of $194,000 in the Blackberry basin. Damage to highways and bridges in Massachusetts make up 90 percent of this total. Four bridges in New Marlborough, Massachusetts, were wrecked. At the village of Canaan, Connecticut, a milk plant, 40 houses, a playground, and a golf course were flooded.

e. Tenmile River, New York and Connecticut. - The 1938 flood exceeded the 1936 crest stage by approximately one foot but caused no important damage. Damage totaled $15,000 to 10 dwellings, a few stores, and approximately 200 acres of farm land.

f. Still River, Connecticut. - The Still River flows through undeveloped country except in the city of Danbury, which lies in a natural basin where the river is formed by several small streams. The flood of September 1938 caused a loss of one life and direct losses that totaled $103,600 in the city of Danbury, while the flood of March 1936, which was approximately three feet lower, caused direct losses of $24,700. A number of hat factories and the commercial center of the city have experienced severe damage from great floods, and frequent damage from freshet flow which readily overtops the river banks or seeps into basements. The river is very badly constricted within the city by bridges, building foundations, culverts, debris, and filled land.

g. Shepaug River, Connecticut. - The flood of September 1938 caused damage of $63,000 which occurred principally in the town of Washington, where the crest stage of 1936 was exceeded by 2-1/2 feet. At Washington Depot a high-type residential and commercial area, including 20 houses, stores, a railroad station, and public schools, was flooded to a depth of two or three feet with damage totaling over $42,000. Except for the village of New Preston, where a smaller area was affected, damage was principally to the highways which follow the river in this rugged valley.

h. Pomperaug River, Connecticut. - No important losses resulted from the flood of 1938. Direct losses totaled approximately $11,000, of which $5,000 was to roads and bridges. There was also damage to farm land and dwellings. Several families evacuated their homes in South Britain, Connecticut.

4. CLASSIFICATION OF FLOOD LOSSES. - The losses which can be assigned a monetary value are classified as follows:

a. Direct losses are the physical damage to property and goods, measured by the present-day cost of repair or the replacement in kind, and the cost of clean-up and moving goods. These have been further subdivided as urban (including residential, commercial, and public losses), rural, industrial, railroad, and highway.

b. Indirect losses are the value of service or use either lost or made necessary by reason of flood conditions, not chargeable to direct loss. They include losses of business and wages, costs of relief, and similar losses both within and without the flood area during the period of flood and subsequent rehabilitation.

c. Depreciation losses are the decreases in the value or utility of property beyond that deducible from direct and indirect losses. These decreases below the normal value, which is regulated by the experienced cycle of floods, have resulted from the new experiences of November 1927, March 1936, and September 1938.

5. RECURRING LOSSES. - Preventable recurring losses are those which will occur with future floods, unless eliminated by flood control works. They have been computed from the losses experienced in the March 1936 and September 1938 floods by eliminating losses which are clearly non-recurring by reason of permanently altered usage or abandonment. Recurring losses are segregated into damage reaches in order to provide areas convenient for the summation of losses and the analysis of benefits from various plans of flood protection. The Housatonic Watershed was divided into 15 reaches or "damage zones" which were subdivided for local protection studies wherever necessary. They were chosen in such a manner that individual tributary effects could be readily ascertained, and locations with high concentrations of damage could be segregated. In each damage zone a definite reference gage with a good stage-discharge relation serves as an index to stages throughout the reach. The damage

zones are described in Table III and shown on Plate No. 1. Table IV summarizes the recurring direct losses by damage zones, based upon the flood of 1938.

6. DISCHARGE-LOSS RELATIONSHIP. - The relation between direct loss and stage, referenced to the September 1938 flood crest, was determined for each large industry or important property and for separate residential, commercial, and other areas. The relation was established for a range in stage extending from the beginning of damage to the level of the flood having a 0.1 percent chance of occurrence, using the recurring preventable losses of the September 1938 and the March 1936 floods as a control. The individual losses were related to stage at the index station for the reach and summated for one-foot increments of stage. Curves of total direct recurring losses versus stage and discharge at the index station were prepared for each damage zone. Similar curves were prepared for individual areas wherever they were required by studies of local protection.

7. DISCHARGE-FREQUENCY RELATIONSHIP. - Discharge-frequency curves have been plotted for those United States Geological Survey gaging stations in the Housatonic Watershed, where sufficient data on recent, as well as historical floods, were available to assure well-defined frequency curves. Curves of discharge per square mile versus drainage area in square miles have been plotted with frequency as a parameter. The discharge-frequency curves at index stations were obtained from these general relationships.

8. AVERAGE ANNUAL DIRECT LOSSES. - The damage-frequency relationship was obtained for each damage zone from the relationship of damage to discharge derived above, and the discharge-frequency relation from record. The natural damage-frequency relation was plotted between 100 and 1.0 percent chance. Between 1.0 percent and 0 percent chance the

TABLE III - APPENDIX B

DESCRIPTION OF DAMAGE ZONES
HOUSATONIC RIVER WATERSHED

ZONE NO.	RIVER	STATE	DESCRIPTION OF ZONE	INDEX STATION
1A	Housatonic	Mass.	From Hinsdale dam site (1.2 miles above Hinsdale) to East Street Bridge above "Lakewood," Pittsfield, Mass.	U.S.G.S. gage at Coltsville, Pittsfield, Mass.
1B	Housatonic	Mass.	From East Street Bridge above "Lakewood," Pittsfield, Mass., to West Branch of Housatonic	Van Sickler Dam, Pittsfield, Mass. (Dale Bros. Laundry)
2	West Branch Housatonic	Mass.	From above Lanesborough to junction with Housatonic River	Pittsfield, Mass.
3	Williams	Mass.	From New York-Massachusetts State line to mouth	West Stockbridge, Mass.
4	Housatonic	Mass.	From junction with West Branch to Van Deusenville Highway Bridge	U.S.G.S. gage near Great Barrington, Mass.
5	Housatonic	Mass.	From Van Deusenville to Massachusetts-Connecticut State line	Dam of Southern Berkshire Power and Electric Co.
6	Blackberry	Conn.	From Norfolk, Conn., to mouth at Canaan, Conn.	Canaan, Conn.
7	Housatonic	Conn.	From Massachusetts-Connecticut State line to junction with Tenmile River	U.S.G.S. gage at Falls Village, Canaan, Conn.
8	Tenmile	Conn. & N.Y.	From Millerton, N. Y., on Webatuck Creek to mouth of Tenmile	U.S.G.S. gage near Gaylordsville, New Milford, Conn.
9	Still	Conn.	From above Danbury, Conn., to mouth	U.S.G.S. gage near Lanesville, New Milford, Conn.
10	Housatonic	Conn.	From Tenmile River to junction with Shepaug River	Robertson Bleachery & Dye Works Dam, New Milford, Conn.
11	Shepaug	Conn.	From West Morris, Conn., on Bantam River to mouth of Shepaug	U.S.G.S. gage near Roxbury, Conn.
12	Pomperaug	Conn.	From North Woodbury, Conn., to mouth	U.S.G.S. gage at Southbury, Conn.
13	Housatonic	Conn.	From junction with Shepaug River to tide-water at Derby, Conn.	U.S.G.S. gage at Stevenson, Oxford, Conn.
14A	East Branch Naugatuck	Conn.	From railroad bridge at upper end of Torrington to East Main Street Bridge, Torrington, Conn.	U.S.G.S. gage near Thomaston, Conn.
14B	Naugatuck	Conn.	From West Torrington to bridge at junction of South and North Main Streets, Torrington, Conn.	U.S.G.S. gage near Thomaston, Conn.
14E	Naugatuck	Conn.	From Naugatuck River and East Branch Bridges at Main Street, Torrington, Conn., to Thomaston site	U.S.G.S. gage near Thomaston, Conn.
14F	Naugatuck	Conn.	From Thomaston site to Watertown-Waterbury town line	U.S.G.S. gage near Thomaston, Conn.
15	Naugatuck	Conn.	From Watertown-Waterbury town line to Ansonia-Derby town line	U.S.G.S. gage near Naugatuck, Conn.
16	Housatonic	Conn.	From tidewater at Derby, Conn., to mouth	Derby, Conn.

curve was distorted to the value of the direct loss from one flood having a 0.1 percent chance of occurrence. The average annual direct loss was then taken as the mean ordinate of the entire 100 percent chance period. Average annual direct losses are summarized in Table IV.

9. INDIRECT LOSSES. - The indirect losses were computed as a constant percentage of the direct losses in each locality. The percentage was determined by application of empirical ratios to the direct recurring losses of each type, and weighing these as they occurred in the flood of 1938. The ratios are as follows:

Residential	0.40	Railroad	1.00
Commercial	0.70	Highway	1.00
Industrial	1.20	Agricultural	0.20
Utility	1.00	Public	0.50

The above ratios are based upon studies in the Housatonic River Watershed and other similar areas of the Providence District. Average annual indirect losses are summarized in Table IV.

10. DEPRECIATION LOSSES. - Decreases in property values, as a result of recent floods, have occurred only in a few relatively small areas. Damage from recent floods, although important, has been small relative to the value of property and the losses that may be expected from floods slightly greater than those experienced in recent years. Large depreciation losses could and would result from a great flood, particularly in the highly industrialized areas of the Naugatuck River, where Torrington, Waterbury, and Ansonia would suffer great losses. At present, depreciation losses exist only in a few areas. At Waterbury, Connecticut, a residential area, which was already blighted and degraded in appearance, reflects a further decrease in value as a result of flooding in the basement and to the first floor approximately four times in as many years. The Lakewood area of Pittsfield, Massachusetts, near the headwaters of the Housatonic River, includes about 100 dwellings located in a natural overflow area. These properties have been depressed in value

TABLE IV - APPENDIX B

FLOOD LOSSES BY DAMAGE ZONES

HOUSATONIC RIVER WATERSHED

Damage zone	River	Recurring direct losses		Existing depreciation of real estate from floods of 1936 and 1938**	Average annual losses			
		September 1938 stage	Maximum flood stage*		Direct	Indirect	Depreciation**	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1a	Housatonic	$ 44,500	$ 239,300	$ 0	$ 9,800	$ 5,200	$ 0	$ 15,000
1b	Housatonic	(1) 39,400	500,000	77,000	8,400	6,000	2,700	17,100
2	Housatonic West Branch	30,000	216,500	0	3,000	1,900	0	4,900
3	Williams	14,200	84,000	0	900	700	0	1,600
4	Housatonic	131,100	1,066,100	0	27,500	23,400	0	50,900
5	Housatonic	56,500	882,200	0	12,700	9,500	0	22,200
6	Blackberry	39,700	142,000	0	2,100	1,600	0	3,700
7	Housatonic	43,800	522,000	0	6,400	5,400	0	11,800
8	Tenmile	14,900	56,500	0	900	400	0	1,300
9	Still	106,000	1,346,000	0	18,600	17,300	0	35,900
10	Housatonic	77,600	570,000	9,000	9,400	8,900	300	18,600
11	Shepaug	58,800	354,000	0	8,700	5,900	0	14,600
12	Pomperaug	9,700	120,000	0	3,400	3,200	0	6,600
13	Housatonic	(2)147,200	968,000	0	10,600	10,300	0	20,900
14a	Naugatuck	37,000	388,000	0	13,500	9,200	0	22,700
14b	Naugatuck	26,000	812,000	0	9,900	10,900	0	20,800
14e	Naugatuck	23,000	216,000	0	2,800	2,200	0	5,000
14f	Naugatuck	10,900	315,000	0	3,300	3,300	0	6,600
15	Naugatuck	195,700	13,200,000	22,000	171,100	148,800	800	320,700
16	Housatonic	Tidewater	- -	0	0	0	0	0
	Totals	1,106,000	21,997,600	108,000	323,000	274,100	3,800	600,900

* Stage of flood having a 0.1 percent chance of occurrence.

** Exclusive of direct and indirect losses. Column (8) computed from column (5) at 3.5 percent annually.

(1) Improvements at Van Sickler Dam reduce the loss corresponding to 1938 peak discharge to $30,000.

(2) 1938 crest stage was increased by hurricane wave. Recurring loss corresponding to 1938 peak discharge equals $40,000.

since the inception of the area and values have been further decreased by the several recent floods. Another area where depreciation losses exist is at New Milford, Connecticut, in a small new commercial area, which had been growing until flooded to a depth of five feet by the flood of September 1938. To determine depreciation losses, the decreases in value due to recent floods were estimated, allowing for economic changes, by comparison of true sales, reductions in assessments, and opinions of bankers, real estate operators, owners, tenants, and other qualified individuals. The existing depreciation from the floods of 1936 and 1938, as summarized in Table V, has been adjusted to exclude the capitalized value of annual direct and indirect losses. Annual depreciation losses were determined upon the basis of (1) an average capital loss during the 50-year life of protective works equal to one-half of the observed depreciation and (2) an annual loss of five percent to the property owners, and a two percent tax loss to the community. Annual depreciation losses are summarized in Table IV.

11. POTENTIAL INCREASES OF PROPERTY VALUE. - Potential increases in land value, from the protection of unimproved lands, are possible in many areas where development has been retarded by floods. Benefits to flood control would result from the more productive use of the land which would follow protection. Many areas of the watershed which are now subject to frequent overflow would otherwise be in demand for industrial expansion or residential and commercial growth. Increases were taken as the difference between present and potential values as summarized in Table VI, based upon weighing of the various factors that control present and future value. The potential increase totals $649,000, which is equivalent to an annual benefit, at 5 percent, of $32,900, were complete protection provided.

TABLE V - APPENDIX B

DEPRECIATION AND VALUATION DATA, AND
POTENTIAL INCREASES IN LAND VALUES
HOUSATONIC RIVER WATERSHED

DAMAGE ZONE	RIVER	STATE	REAL ESTATE VALUATION 1938 FLOOD AREA (PRE-FLOOD)	REAL ESTATE VALUATION MAXIMUM FLOOD AREA*	REAL AND PERSONAL PROPERTY VALUATION, MAXIMUM FLOOD AREA*	EXISTING DEPRECIATION OF REAL ESTATE FROM FLOODS OF 1936 AND 1938**	POTENTIAL INCREASE OF LAND VALUES, WITH PROTECTION
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Housatonic	Mass.	$ 3,204,000	$17,752,000	$31,567,000	$77,000	$73,000(1)
2	Housatonic	Mass.	980,000	2,122,000	4,418,000	0	0
3	Williams	Mass.	66,000	278,000	460,000	0	0
4	Housatonic	Mass.	1,579,000	4,216,000	8,346,000	0	0
5	Housatonic	Mass.	361,000	459,000	1,019,000	0	0
6	Blackberry	Conn.	145,000	260,000	400,000	0	0
7	Housatonic	Conn.	71,000	325,000	455,000	0	0
8	Tenmile	N.Y.& Conn.	19,000	45,000	69,000	0	0
9	Still	Conn.	1,238,000	1,504,000	3,074,000	0	0
10	Housatonic	Conn.	618,000	4,754,000	8,804,000	9,000	16,000
11	Shepaug	Conn.	277,000	457,000	725,000	0	0
12	Pomperaug	Conn.	30,000	275,000	551,000	0	0
13	Housatonic	Conn.	2,906,000	8,956,000	17,922,000	0	0
14	Naugatuck	Conn.	1,935,000	15,916,000	27,777,000	0	0
15	Naugatuck	Conn.	9,406,000	29,594,000	64,900,000	22,000	560,000
Total real and personal property					170,487,000		
Tax-exempt property affected (public and highway)					13,459,000		
Railroad property affected (approximate)					3,315,000		
TOTALS			22,835,000	86,913,000	187,261,000	108,000	649,000

* Area flooded by flood having 0.1 percent chance of occurrence.
** Exclusive of direct and indirect loss.
(1) Including buildings.

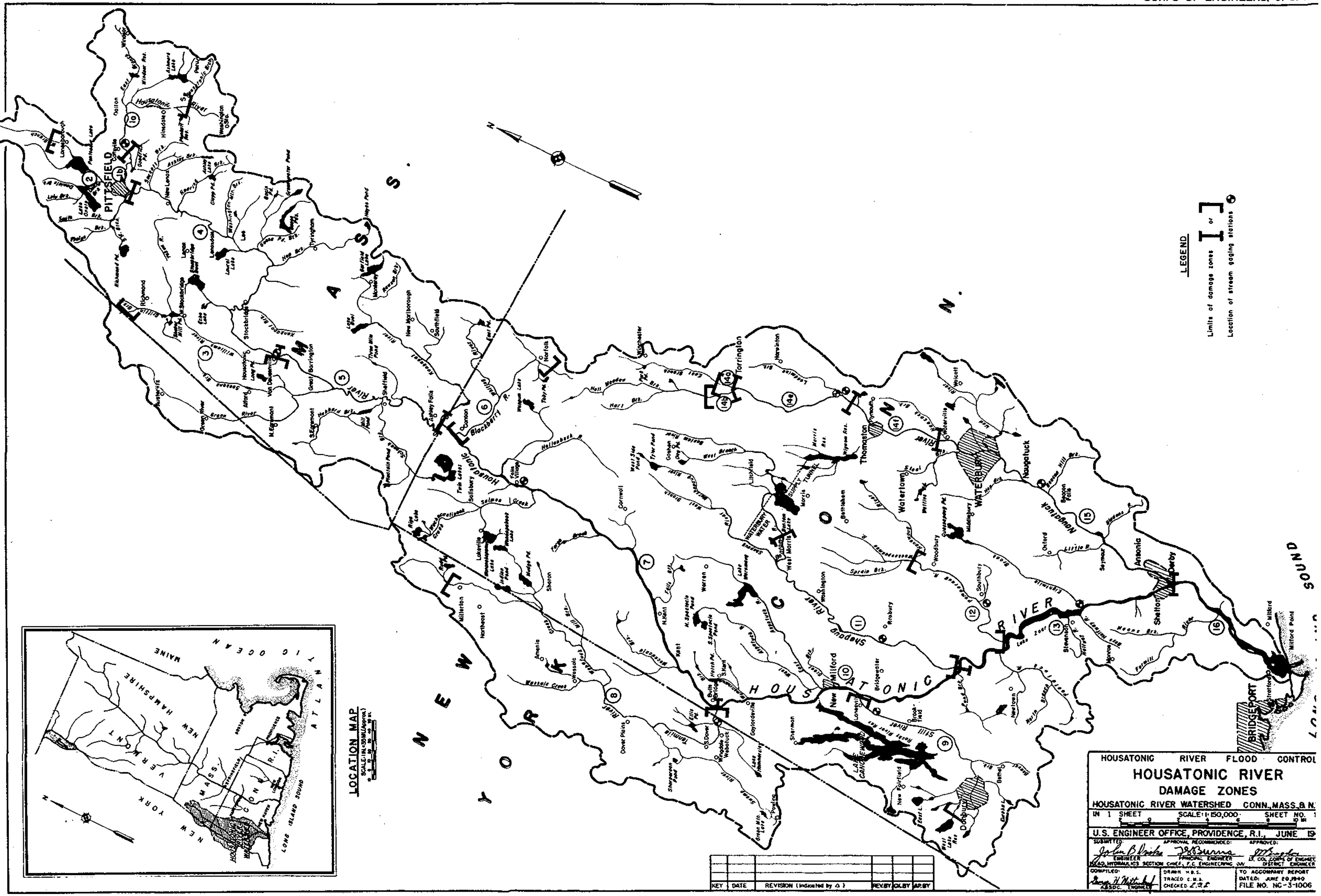
TABLE VI - APPENDIX B

POTENTIAL INCREASES IN LAND VALUES
HOUSATONIC RIVER WATERSHED

	Location			Dam- age zone	Area in acres	Before protection		After protection			Net potential increase of value
	City	State	River			Unit value	Total value	Unit value	Potential value	Potential use	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	Pittsfield	Mass.	Housatonic	1	275	$ -	$400,000*	$ -	$ 473,000*	Residential	$ 73,000*
2	New Milford	Conn.	Housatonic	10	5	7**	14,000	15**	30,000	Commercial	16,000
3	Derby	Conn.	Naugatuck	13	10	100	1,000	3,000	30,000	Industrial	29,000
4	Derby	Conn.	Naugatuck	13	22	45	1,000	3,000	66,000	Industrial	65,000
5	Derby	Conn.	Naugatuck	13	10	100	1,000	3,000	30,000	Industrial	29,000
6	Derby	Conn.	Naugatuck	13	25	40	1,000	3,000	75,000	Industrial	74,000
7	Waterbury	Conn.	Naugatuck	15	25	520	13,000	3,000	75,000	Industrial	62,000
8	Waterbury	Conn.	Naugatuck	15	25	400	10,000	4,000	100,000	Industrial	90,000
9	Waterbury	Conn.	Naugatuck	15	31	193	6,000	2,000	62,000	Industrial	56,000
10	Naugatuck	Conn.	Naugatuck	15	20	100	2,000	1,000	20,000	Recreational	18,000
11	Naugatuck	Conn.	Naugatuck	15	10	1,500	15,000	3,000	30,000	Recreational	15,000
12	Ansonia	Conn.	Naugatuck	15	50	60	3,000	2,500	125,000	Industrial	122,000
	Totals				508		467,000		1,116,000		649,000

* Including buildings.
** Unit value per front foot (2000 front feet 100 feet deep).

12. <u>AVERAGE ANNUAL BENEFITS</u>. - Average annual losses prevented are equivalent to benefits. Direct benefits were computed from the reduction in annual recurring direct losses, as outlined in the report. Benefits accruing to reservoirs were computed first, and benefits accruing to channel improvements or levees were computed from the residual losses. Annual indirect benefits were computed from the direct benefits by application of the percentage determined for each damage zone, as described in Paragraph 9. Restoration benefits were computed from the recoverable depreciation losses in proportion to value of real estate receiving complete protection. Enhancement benefits which result from increases above the normal value prior to 1936, as described above, have not been assigned to proposed protection works because complete protection against a maximum flood is not provided. Average annual benefits due to the proposed Thomaston Reservoir amount to $150,600 of direct benefits, $131,000 of indirect benefits, and $400 of restoration benefits, making a total of $282,000.


HOUSATONIC RIVER FLOOD CONTROL
HOUSATONIC RIVER
DAMAGE ZONES
HOUSATONIC RIVER WATERSHED CONN., MASS. & N.
IN 1 SHEET SCALE: 1:150,000 SHEET NO. 1
U.S. ENGINEER OFFICE, PROVIDENCE, R.I., JUNE 19
SUBMITTED: ENGINEER HEAD, HYDRAULICS SECTION
APPROVAL RECOMMENDED: PRINCIPAL ENGINEER CHIEF, F.C. ENGINEERING DIV.
APPROVED: LT. COL. CORPS OF ENGINEERS DISTRICT ENGINEER
COMPILED: ASSOC. ENGINEER
DRAWN H.B.S. TRACED E.M.A. CHECKED
TO ACCOMPANY REPORT DATED: JUNE 20, 1940 FILE NO. HC-3-1006
KEY DATE REVISION (Indicated by △) REV.BY CK.BY AP.BY
LEGEND
Limits of damage zones
Location of stream gaging stations
LOCATION MAP
MASS.
CONN.
NEW YORK
VERMONT
NEW HAMPSHIRE
MAINE
ATLANTIC OCEAN
LONG ISLAND SOUND
M A S S.
C O N N.
N E W Y O R K
HOUSATONIC RIVER
PITTSFIELD
TORRINGTON
WATERBURY
BRIDGEPORT
LAKE CANDLEWOOD
LONG ISLAND SOUND

APPENDIX C - LOCAL PROTECTION WORKS

APPENDIX C - LOCAL PROTECTION WORKS

Levees, Walls, and Channel Improvements

1. LOCALITIES STUDIED. - In addition to the studies described in paragraphs 45 and 46 of the main report, studies have been made in the Housatonic River Watershed to determine the feasibility of providing individual protection to a number of other small local damage centers which have suffered appreciable losses during past floods. It was found that local protection in the form of levees, walls, or channel improvements was not justified to any of the damage centers discussed in the following paragraphs. The areas on the Housatonic and Naugatuck Rivers are listed in downstream order. The areas on the tributaries are then listed in downstream order as the tributaries enter the Housatonic and Naugatuck Rivers. At a number of locations, preliminary investigation of losses and costs of protection precluded any further study because the ratio was obviously very unfavorable. Details of the works considered, estimates of their cost, and benefits which may be credited to them are in the files of the Providence District. Studies were advanced only to such stage as the size and importance of the locality, the magnitude of the losses, or the probability of justification warranted.

2. HINSDALE, MASSACHUSETTS.

a. General. - The March 1936 flood exceeded the more recent flood of September 1938 by several feet, due to the failure of Plunkett Reservoir. Total losses of the March 1936 flood amounted to approximately $30,500. Non-recurring damage to Plunkett Reservoir amounted to $12,200, while all the remaining losses were to scattered houses and farm land and to highways and railroads.

b. Backwater conditions above Lynholm Company dam. - The property in the village of Hinsdale that could be protected by removing the Lynholm Company dam consists of three two-family houses, a town garage, a blacksmith shop, and a block of stores, all of which would be affected by a flood greater than the record flood of March 1936 which caused direct damages of approximately $1200 in this section. All of this property is in a poor state of repair. Conditions in this section could be improved by removing the Lynholm dam. A natural gorge forms a control just below the dam. The waterway area would have to be increased and a small access bridge removed. Above the dam the channel would have to be cleaned, straightened, and enlarged to a uniform section with a bottom width of 40 feet and a depth of 8 feet. Some of this excavation would be in rock. The total length of the improvement would be approximately 1500 feet.

3. DALTON, MASSACHUSETTS.

a. General. - Direct losses in the September 1938 flood amounted to $42,500. Of the total, $15,000 was to scattered agricultural land and buildings. Large highway losses occurred along small streams, and two mill buildings sustained small losses. The remainder of the loss was sustained by the Pioneer Mill.

b. Protection for the Pioneer Mill of the Crane Company. - The Pioneer Mill of the Crane Company is a paper mill employing about 250 people. The valuation of land and buildings is approximately $850,000. The September 1938 flood covered the grounds about one foot deep, filled the basement, and caused damage of approximately $4900. The plant was not shut down and no indirect loss resulted from the flood. The protection would consist of a concrete wall approximately 800 feet long and 7 feet high, and would extend from the dam along the bank of the river to the mill, and thence around the mill to high ground near a building used as a museum. Headgates would be provided at the head of the canal. A pumping station would be required to provide for the natural drainage.

4. PITTSFIELD, MASSACHUSETTS - WEST BRANCH OF HOUSATONIC RIVER.

a. General. - Direct losses from the September 1938 flood in Pittsfield amounted to $148,500 for both branches of the river. Three plans of local protection for the Housatonic River in Pittsfield above Van Sickler Dam are discussed in paragraph 44 of the main report. The conditions on the West Branch are discussed in the following paragraphs.

b. West Branch of the Housatonic River. - In the reach of river from Boylston Street to Bel Air Street, the September 1938 flood caused direct damage amounting to $24,300. In this section the Airdale Dam is located 500 feet downstream from West Housatonic Street, and the dam at Plant No. 4 of the Eaton, Crane and Pike Paper Company is located 1400 feet above Housatonic Street. After the March 1936 flood, a Works Progress Administration program was initiated by the City of Pittsfield to improve the section of river beginning at a point 1000 feet above the dam at Plant No. 4 of the Eaton, Crane and Pike Paper Company and extending to Wahconah Street. This project was complete at the time of the September 1938 flood and materially reduced flood stages at that time. The channel in its present condition will not pass the September 1938 flood discharge of 2500 cubic feet per second without some damage. The March 1936 flood discharge was estimated to be less than the September 1938 flood discharge by inspection of flood elevations at several points above and below the dam at Plant No. 4 of the Eaton, Crane and Pike Paper Company. Although the peak discharge of the September 1938 flood exceeded that of the March 1936 flood, direct losses of the September 1938 flood amounted to only $24,300, while the direct losses of the March 1936 flood amounted to $27,000. Improvements at the Eaton, Crane and Pike Paper Company dam and at bridges and other constricted sections effected considerable reduction in the stage of the September 1938 flood and have generally improved the ground-water conditions, particularly during flood times. The maximum probable flood is greater than either the 1936 or the 1938 flood and would cause greater damage. The measures taken would alleviate the losses but would not control such a flood.

c. Possible improvement of conditions at the Airdale Dam. - The only purpose for which the pool behind the Airdale Dam of the Eaton, Crane and Pike Paper Company is maintained is to provide a supply of water for fire protection. This company has recently obtained permission from the Fire Insurance Underwriters to lower the water surface 20 inches, which is equivalent to the height of the permanent flashboards on the dam. If these flashboards were removed, objectionable mud flats would be exposed. The Eaton, Crane and Pike Paper Company is desirous of having the City of Pittsfield assume the responsibility for any damages which may result from lowering the water surface.

d. Possible improvement of conditions at the dam of Plant No. 4 of the Eaton, Crane and Pike Paper Company. - Channel conditions above the dam of the Eaton, Crane and Pike Paper Company Plant No. 4 could be improved further by excavation to a uniform section. Several large areas near this dam are subject to frequent damage by overflow of the river, or by high ground-water conditions aggravated by high stream stages.

e. Summary. - Complete protection against flood damage on the West Branch of the Housatonic River, between Bel Air Street and Boylston Street, a distance of 16,000 feet, could be provided, but the total cost would greatly exceed the total benefits. No further studies were made of this section of the river.

5. LENOX, MASSACHUSETTS. - The September 1938 flood caused direct damage of $8500 on the Housatonic River and $20,900 to highways along small streams. Damage on the Housatonic River was principally to railroads,

highways, and farm lands, spread over large areas. There are no highly developed zones in this area at which protection is feasible.

6. LEE, MASSACHUSETTS.

a. General. - Damage caused by the September 1938 flood in the town of Lee amounted to $43,700. The most important damage centers have been studied individually. They are the Columbia and Eagle Mills of the Smith Paper Company, the residential section just below the Laurel Street highway bridge, and the Hurlbut Paper Company. Direct losses to these properties in the September 1938 flood amounted to $8400. The remaining damage was principally to highways and railroads. Additional damage of $32,200 was reported on Goose Pond Brook and other small streams in the town of Lee. Only a small portion of the loss would be recurring, because of improvements, reconstruction, and protective measures taken by the Massachusetts Department of Public Works. Of the four locations investigated, only the protection at the Columbia Mill was found to be justified. Conditions at the Columbia Mill are fully discussed in paragraph 45 of the main report. Conditions at the other three locations are discussed in the following paragraphs.

b. Vicinity of Eagle Mill of the Smith Paper Company. - The Eagle Mill of the Smith Paper Company is a modern paper mill employing 200 people and having a value approximating $1,000,000. The plant is actively operating and has, within the last year, constructed a new building at a cost in excess of $50,000. The September 1938 flood caused direct losses of $2900. The lower floor of the building below the dam was flooded to a depth of one foot, and the grounds were flooded to a depth of two feet. Protection could be afforded to this mill by the construction of a section of concrete wall 7 feet high and 400 feet long, a section 9 feet high and 500 feet long, and by waterproofing one wall for a distance of 400 feet. A stop-log structure would have to be built at the railroad track, provisions would have to be made to sand-bag United States Highway No. 20 in case of high water, and a small pumping plant would be necessary. New headgates would have to be installed at the dam.

c. Below Laurel Street bridge, left bank. - The residential section below the Laurel Street highway bridge is a small settlement of about nine houses and a variety store between Laurel Street bridge and the railroad station. The September 1938 flood inundated the area to a depth of about two feet and caused damage of approximately $100,000. An earth levee approximately 1200 feet long and 12 feet high would protect this section. The levee would extend from the bridge of United States Highway No. 20, around the residential section to high ground near the railroad station. Some provision for natural drainage would be necessary.

d. Vicinity of Hurlbut Paper Company mill. - The Hurlbut Paper Company is a paper mill employing about 75 persons. Land and buildings appear to be in fair condition, with a value of approximately $250,000. The flood of March 1936 caused very small losses. The flood of September 1938 caused damage of $2200 to grounds and retaining walls which were flooded two feet deep, and caused a shut-down of ten days with a total loss of production and wages reported at $23,600. Greater floods would affect the first floor of the plant and result in direct losses of approximately $35,000. Protection could be provided for this mill by the construction of a concrete wall along the left abutment of the dam, 200 feet long and 4 feet high, and by construction of a concrete wall around the mill, 900 feet long and 9 feet high. Provisions would have to be made for new headgates and gate structures in the dam. The right abutment would have to be raised approximately four feet and extended to high ground.

The channel would have to be excavated, and riprap would have to be placed where necessary on both sides of the river. Some provision for natural drainage would be necessary.

7. STOCKBRIDGE, MASSACHUSETTS.

a. General. - The reach of river from the Glendale Dam to South Lee is subject to yearly flooding. Principal damage caused by this flooding occurs to the Stockbridge Golf Course, a privately owned course. During the September 1938 flood, 17 of the 18 greens of this golf course were under water. Direct losses caused by the September 1938 flood in the town of Stockbridge amounted to $50,300. Of this amount $23,300 occurred at the Stockbridge Golf Course and the East Main Street section. The remaining losses in the town were almost entirely to highways and railroads.

b. East Main Street section. - An earth levee approximately 700 feet long and 15 feet high would provide protection for a small commercial section against a flood stage six feet higher than the September 1938 flood. A pumping plant would be necessary to accommodate the natural drainage. The principal property is a lumber yard which has land and buildings of a value less than $20,000. The lumber yard sustained damage of approximately $8000 from the September 1938 flood and $5100 from the March 1936 flood.

c. Vicinity of the Golf Course, right bank. - An earth levee on the right bank, approximately one mile long and 15 feet high, supplemented by channel straightening and excavation to a uniform section, would protect the major portion of the golf course, tennis courts, and adjoining club-house, coal yard, garage, and eight houses. The flood of September 1938 caused direct losses of $6300, and the flood of March 1936 caused similar damage. The golf course is located in the normal flood plain of the river and so is flooded on an average of once a year.

d. Vicinity of the Golf Course, left bank. - Protection could be afforded to the golf course on the left bank by the construction of a levee 1000 feet long and 15 feet high. This levee would also protect two houses, the railroad station, and tracks.

e. Glendale Dam. - It would be possible to provide some benefit to the golf course and to the commercial and residential sections in Stockbridge by placing crest gates on the Glendale Dam approximately three miles below the golf course. The annual cost of the gates alone is nearly equal to the annual benefits. Therefore the total cost of the project, which would also include extensive alteration of the present dam, cannot be justified.

8. GREAT BARRINGTON, MASSACHUSETTS.

a. General. - General conditions in the town of Great Barrington are discussed in paragraph 46 of the main report. The specific situation at the Monument Mills is discussed in detail in paragraph 46 a. Conditions at the Rising Paper Company and the fair grounds of the Housatonic Agricultural Society are discussed in the following paragraphs.

b. Vicinity of Rising Paper Company. - The mill is operated by the Strathmore Paper Company and employs 250 people. It is fully utilized and actively operated. The September 1938 flood caused direct damage of $5700 and indirect losses of $6900 from a shut-down of six days. The property of the Rising Paper Company is now being protected against a flood equal to the maximum flood of record, by the State of Massachusetts. The protection consists of a flood wall of wood piling driven into the ground, with rock fill placed on both sides. The river has been dredged, widened, and straightened. No estimate can be made of the channel capacity without a survey, but it will probably be great enough to pass the flood of record without serious damage. Complete protection could be provided for this mill by the construction of a concrete wall 1700 feet long and 9 feet high, extending from the spillway of the canal around the mill to the highway. Gates would have to be provided on the canal, and a pumping plant would be necessary.

c. Housatonic Agricultural Society fair grounds. - Protection to the fair grounds could be provided by the construction of an earth levee approximately 4000 feet long and 15 to 18 feet high. It would be necessary to straighten the river, excavate to a uniform channel, and provide for natural drainage.

9. SHEFFIELD, MASSACHUSETTS. - The total damage caused by the September 1938 flood amounted to $11,300 on the Housatonic River and $16,400 on the Konkapot River and other small streams. Losses were chiefly to highways and railroads and to a few small industries, dwellings, and scattered farms. No individual protection was considered worthy of study.

10. NORTH CANAAN, CONNECTICUT. - Damage by the Housatonic River is not important because the river banks are steep and there is little development near the river. No individual locations were considered worthy of study.

11. SALISBURY, CONNECTICUT. - Direct losses due to the September 1938 flood amounted to $10,900. Losses were chiefly to rural property and a few scattered buildings. No local protection studies were made.

12. CANAAN, CONNECTICUT. - Direct losses on the Housatonic River were $7000 from the September 1938 flood. Losses were principally to highways and railroads, and no protection measures for them were studied.

13. SHARON, CONNECTICUT. - Total direct losses due to the September 1938 flood amounted to $12,000. Approximately $8000 was to houses and summer cottages opposite West Cornwall. One cottage was washed away.

Recurring losses amounted to only $2000 urban and $1600 highway. The valley is generally deep and narrow. No protection measures were studied.

14. CORNWALL, CONNECTICUT. - The September 1938 flood caused damage amounting to $15,400, all to highways and railroads on the Housatonic and small streams, except for $1600 damage to urban property at Cornwall Bridge. No individual protection studies were made.

15. KENT, CONNECTICUT. - Direct losses due to the September 1938 flood totaled $18,700. Damage was almost entirely to highways and railroads, and no protection studies were made.

16. NEW MILFORD, CONNECTICUT.

a. General. - Direct losses caused by the September 1938 flood totaled $90,400, of which $15,300 occurred to highways on the East and West Aspetuck Rivers and other small streams. Most of the losses occurred in the city of New Milford, where direct losses totaled $66,200 in areas studied for local protection. The only other important loss was occasioned by flooding of the Bulls Bridge hydroelectric station.

b. Left bank, above highway bridge. - The area lies between two small creeks on the left bank of the Housatonic River above the highway bridge in New Milford. The levees would run back up the creeks to high ground near the railroad. An earth levee approximately 2000 feet long and 9 feet high would protect a scattered residential section and a small commercial area. Some provision for natural drainage would be necessary.

c. Left bank, ring dike around Robertson Bleachery and Dye Works. - The bleachery is a large plant employing 270 people. The plant is fully utilized and has a book value of $1,500,000. The September 1938 flood caused direct damages amounting to $37,300, although much of the loss was covered by insurance. Partial protection since the September 1938 flood permits moving of stock, so that direct recurring losses from a flood similar to that of September 1938 would be reduced to $5000. Indirect losses from the September 1938 flood amounted to $14,000. The management of the plant does not seem to be particularly interested in any extensive flood protection measures for the plant. Protection to the mill can be provided by the construction of an earth levee on three sides of the mill, with a total length of 1500 feet and an approximate height of 16 feet. An 800-foot concrete wall five feet high would have to be built along the railroad. A pumping station would have to be provided and flood gates would also have to be installed at the exit portal of the waste channels.

d. Right bank, below highway bridge. - The area which would be protected includes a few houses and about 12 commercial buildings which were flooded about four feet deep in the September 1938 flood. This small commercial center has over 2000 linear feet fronting on the main artery of travel into the Berkshires, which insures future growth if flood protection is provided. Direct losses from the flood of September 1938 totaled $20,200. Protection to this area could be provided by an earth levee 3800 feet long and 12 foot high, and two stop-log structures. A pumping station would be required.

17. BROOKFIELD, BRIDGEWATER, NEWTOWN, AND SOUTHBURY, CONNECTICUT. - Flood losses in these towns are very small and scattered, and are mostly to highways. The valley is deep and narrow, and there are no important developments along the river. No flood protection studies were made in these towns.

18. MONROE, OXFORD, AND SEYMOUR, CONNECTICUT. - The Housatonic River caused important damage in the September 1938 flood. Failure of the flashboards at Stevenson Dam resulted in a loss of $2500 to the Connecticut Light and Power Company. Cottages at Oxford were damaged to the extent of about $2000. Most loss occurred in Seymour on the Housatonic River. No flood protection studies were made in these towns.

19. SHELTON, CONNECTICUT.

a. General. - Direct losses for September 1938 totaled $75,100. These losses are all included in the local protection area discussed in the following paragraph, except for a few thousand dollars loss to highways and railroads. It is to be noted that the crest stage of the September 1938 flood was increased by the hurricane wave, so that recurring losses with the same discharge will be considerably less. Losses due to the March 1936 flood were important, but no complete record is available.

b. Right bank of Housatonic River in the city of Shelton. - The area affected is a concentrated group of diversified industrial buildings between a canal and the river. About 4000 people are employed, and the area has a total value close to $8,000,000. Direct losses of the September 1938 flood were small in relation to the value of the plants and amounted to $69,200. Protection to this area could be provided by the construction of a concrete wall about 5500 feet long and at least 10 feet high. Provision for flood gates would be required at all outlets from the canal, and a pumping station would be required to take care of natural drainage and the leakage from the canal. The September 1938 high water at Shelton occurred at about 8:00 p.m. on the 21st and was caused by a combination of the high tide (6 feet above normal high tide, or 8-1/2 feet above mean sea level) and a discharge from the Housatonic River of 54,000 cubic feet per second. The peak discharge of 60,600 cubic feet per second on the Housatonic River occurred at 1:00 a.m. on September 22, and by this time the tide had receded more than enough to offset the increase in river stage due to this discharge.

20. DERBY, CONNECTICUT.

a. General. - The direct losses of the September 1938 flood amounted to $65,800, with indirect losses of about the same amount. All the losses are included in the areas studied for local protection, except highway and railroad losses amounting to $10,000. The property which would be protected includes nine industrial plants and a power station, as well as considerable commercial and some low-type residential properties. Property in the area has a total valuation of approximately $4,500,000. Approximately 110 acres of low land with potential industrial usage are included within the proposed protection area. Several different plans of protection in this area have been investigated. It is obvious that since no single plan for protection at Derby is justified, no combination of plans is justified.

b. Plan I. - From Shelton bridge to and including the Philgas Company plant. - This plan would provide protection against a very rare flood. It would consist of a concrete wall 800 feet long and 10 feet high, an earth levee 600 feet long and 16 feet high, two sections of earth levee along the existing railroad embankment 3500 feet long and 16 feet high, and an earth levee 1000 feet long and 16 feet high extending to high ground. Riprap would be placed where necessary. A pumping station would be necessary, and extensive alterations to the existing sewer system would be required.

c. Plan II. - From Shelton bridge to and including the Philgas Company plant. - This plan would provide complete protection for this area. The plan is identical with Plan I, except that protection would be provided to a stage 2.6 feet higher than in Plan I.

d. Plan III. - From Shelton bridge to Division Street bridge. - This plan would provide complete protection to this area. It includes the same area as Plan I and also an area of 29 acres of idle land between Main Street and Division Street which is desirable for industrial development. The levee grade would be the same as in Plan I. The construction would be the same as in Plan I, and the earth levee would be extended around the undeveloped area.

e. <u>Plan IV. - From Shelton bridge to Bridge Street between Derby and Ansonia.</u> - This plan would provide complete protection to this area. The area includes the same area as Plan III and also additional undeveloped land, of which approximately 28 acres lie in the town of Derby and 50 acres lie in the town of Ansonia. The construction would be the same as in Plan III, and the earth levee would be extended around the second undeveloped area.

f. <u>Plan V. - From Shelton Canal Company dam to Cemetery Avenue.</u> - This plan would provide protection against a very rare flood. The construction would consist of a concrete wall 2600 feet long and 6 feet high (above the present ground surface) around the property of three industrial plants and the Derby gas and electric plant. Flood gates and a pumping station would be necessary.

21. <u>TORRINGTON, CONNECTICUT.</u>

a. <u>General.</u> - The September 1938 flood caused direct losses amounting to $83,200 in the town of Torrington, Connecticut. All the losses are included in areas which were studied for local protection. In the section of river just above East Albert Street the City of Torrington has initiated a Work Projects Administration improvement. The improvement consists of a concrete wall approximately four feet in height above the present ground surface, and extends from Harold Street to Lipton Place in the Fuessenich Park section. The original bridge at East Albert Street has been replaced by a modern structure of ample flood capacity and good alinement. Channel improvement work is in progress in the section of the river below East Albert Street, and the channel of Gulf Stream has been enlarged, as has the channel of the East Branch of the Naugatuck River near its mouth. The estimated peak discharge of 6700 cubic feet per second reached during the September 1938 flood is the maximum discharge of record at the East Albert Street bridge. A discharge of 16,000 cubic feet per second is reasonable as a design flood for the region in which Torrington is located. The channel improvement project now under construction will materially improve flood conditions at the sections in question and will reduce flood damage correspondingly. No estimate of the increased channel capacity, after the improvement, has been made, since the work has been done piecemeal and not in accordance with a unified plan, and no surveys have been made of the completed project. Various plans investigated by this office are discussed in the following paragraphs.

b. Channel improvement on East Branch of Naugatuck River. - The property affected includes the Warrenton Woolen Company, the Fitzgerald Manufacturing Company, several other industries, a large portion of the commercial center of the city, and a residential section of approximately 150 homes. Damage from the September 1938 flood amounted to $38,800. Restricted conditions at the Warrenton Woolen Company caused the river to overflow its banks and flow down Main Street, causing extensive damage. Conditions on this branch could be improved by a channel improvement project consisting of straightening the river and excavating to a cross section having a uniform capacity. Obstructions and constrictions in the channel, including two dams and one service bridge, would have to be removed. The total length of the project would be approximately 10,400 feet. Walls would be placed where necessary in the constricted areas.

c. Vicinity of Union Hardware Company. - The September 1938 flood caused damages amounting to $5000. Protection in this area would benefit only the Union Hardware Company. The construction would consist of 800 feet of concrete wall 9 feet high, and 800 feet of earth levee 11 feet high. It would be necessary to build an intercepting sewer from the area protected to below the American Brass Company dam in order to provide for the natural drainage behind the levee. It would also be necessary to provide headgates on the existing canal.

d. Left bank of Naugatuck River between Church Street and Wolcott Avenue. - This is a residential section of 106 homes on the left bank of the Naugatuck River, which is affected by the headwater of the American Brass Company dam located just above Church Street. The September 1938 flood losses amounted to $8300. Protection for this area could be provided by the construction of 1600 feet of concrete wall 7 feet high, and 1200 feet of earth levee 9 feet high. It would be necessary to build intercepting sewers from the area protected to below the dam of the American Brass Company.

e. Channel improvement between Church Street and East Albert Street. - In the area between Church Street and East Albert Street the September 1938 flood caused damage amounting to only $7600, most of which was experienced by the American Brass Company and the Hotchkiss Lumber Company. Potential damage in this section is very high. Protection for this area would be in the form of a channel clearance project 4800 feet long. It would be necessary to place riprap along the banks just below East Main Street. The dam of the American Brass Company, just above Prospect Street, and the dam of the Hotchkiss Lumber Company, just below Church Street, would be removed. Most of the channel excavation would be in rock. It would be necessary to construct approximately 1400 feet of concrete wall on the right bank near the location of the Hotchkiss Dam.

f. Levee on right bank between East Albert Street and King Street. - The property which would be protected includes a residential section of about 70 dwellings, a number of stores, a lumber yard, and a few other commercial units. Direct losses in the area amounted to $9100 from the September 1938 flood. This area was flooded to a depth of about two feet and only basements and a few first floors were affected. Protection to the area could be provided by the construction of an earth levee 4200 feet long and 11 feet high. It would be necessary for the levees to run back up both banks of Gulf Stream to high ground. A pumping station would have to be provided to take care of the natural drainage, and riprap would have to be placed along the right bank of the river.

22. LITCHFIELD AND HARWINTON, CONNECTICUT. - The September 1938 flood caused direct damage of $6100 to highways, and $700 to railroads, in the towns of Litchfield and Harwinton, Connecticut. There are no important developments along the river in these two towns, and no studies for local protection were investigated.

23. THOMASTON, CONNECTICUT. - The towns of Thomaston, Waterbury, Naugatuck, Beacon Falls, Seymour, and Ansonia, Connecticut, are all located below the Thomaston dam site and will receive a high degree of protection from the proposed Thomaston Reservoir. The town of Thomaston, Connecticut, experienced direct losses of $11,400 from the September 1938 flood. The Hallden Machine Company sustained a loss of $5900 from the September 1938 flood. Other damage caused by this flood occurred to railroad and highway properties. Most of these damages would be eliminated by the proposed Thomaston Reservoir.

24. WATERBURY, CONNECTICUT. - Conditions in the town of Waterbury are discussed in detail in paragraph 47 of the main report.

25. NAUGATUCK, CONNECTICUT. - The total direct losses experienced in the September 1938 flood amounted to $51,100. Damage of nearly $18,000 was caused by the flooding of residential and commercial property behind a local levee at Union City. The levee has since been raised to above the September 1938 crest stage. The United States Rubber Company plant sustained damage amounting to $19,000, and the Naugatuck Chemical Company, a subsidiary of the United States Rubber Company, sustained damage amounting to $10,800. The Town of Naugatuck has initiated a Work Projects Administration improvement which is nearing completion. This project consists of straightening the river, clearing the channel of boulders and

debris, and riprapping the banks to an elevation slightly higher than the highest flood of record. Flood damage in this town will be materially reduced by this construction.

26. BEACON FALLS, CONNECTICUT. - The September 1938 flood caused direct damage amounting to $3100 which was confined mostly to commercial buildings. The large plant of the Beacon Falls Rubber Shoe Company was not affected.

27. SEYMOUR, CONNECTICUT. - Direct loss caused by the September 1938 flood in this town amounted to $6200. Cellars in a high-type residential area were flooded. The New Haven Copper Company and the Derby Castings Company each sustained minor losses.

28. ANSONIA, CONNECTICUT.

a. General. - The September 1938 flood caused direct damages amounting to $51,000. An area on the left bank of the Naugatuck River, near Maple Street, is discussed in the following paragraph. Losses in this area, from the September 1938 flood, amounted to $41,800. Scattered residential and commercial properties on the right bank, with highway and railroad losses, make up the remainder of the losses in this town. All of these properties will receive a large measure of protection from the proposed Thomaston Reservoir.

b. Left bank of the Naugatuck River above and below Maple Street. - This is a large area of commercial property, large industrial plants, a railroad station, and freight yards, which was subject to shallow flooding in the September 1938 flood when direct losses amounted to $41,800. The total valuation of this property amounts to approximately $6,600,000. Protection to this area could be obtained by the construction of a concrete wall approximately 4000 feet long and 6 feet high above the ground. This wall would protect an industrial area above Maple Street and a commercial area below Maple Street. Some provision for natural drainage would be necessary.

29. NEW MARLBOROUGH, MASSACHUSETTS. - Direct losses caused by the September 1938 flood totaled $262,300, of which $16,300 was to urban property, and approximately $245,000 to highways. The damage was caused by the Konkapot River and other small streams. Only a small portion of these losses would recur in a similar flood because of reconstruction and channel improvements by the Massachusetts Department of Public Works. No individual protection studies were made for this town.

30. OTHER TOWNS IN MASSACHUSETTS. - Many other towns such as Monterey, Tyringham, and Washington experienced large highway losses. Losses in these towns were not studied in detail. Improvements made by the Massachusetts Department of Public Works subsequent to the September 1938 flood will considerably reduce the amount of damage from future floods in these towns.

31. DANBURY, CONNECTICUT.

a. General. - Danbury is located on the upper Still River, a tributary of the Housatonic River. The river flows through the center of the city. Padanaram Brook, having a drainage area of 8 square miles, joins the Still River, with a drainage area of 7 square miles, just above Patch Street. The river then flows past various mills, crosses under East Franklin Street, the New York, New Haven and Hartford Railroad, and Crosby Street, and is then joined by a branch of the Still River having a drainage area of 16 square miles, giving a total drainage area of 31 square miles. After crossing underneath White Street and passing the railroad yards, the stream traverses a less intensely developed area in which there are several hat factories located on the low flood plain of the stream. Below the city of Danbury, Shelter Rock Brook, with a drainage area of 7 square miles, joins the Still River, making a total drainage area of 39 square miles at this point. The upper section of the Still River between Patch Street and the railroad yards flows through the center of the intensely developed portion of Danbury. Numerous mills, stores, and other buildings are located along the stream banks in this section. In many cases the buildings have encroached upon the normal section of the channel, and in several cases the buildings have been built projecting over the stream or spanning it completely. The branch of the Still River entering just above White Street is completely covered for a distance of some 500 feet above its confluence with the Still River. In flowing under White Street the river is confined for a distance of about 150 feet. Where buildings have been built over the stream, the channel is obstructed by numerous stone piers or columns in addition to the foundation walls of the buildings. The stream is extensively used as a dumping ground for refuse and garbage; and at points where the stream banks are exposed, debris of all sorts has been indiscriminately dumped and has seriously reduced the normal channel carrying capacity. This haphazard dumping has also created an unsightly condition and a public health menace. The numerous constrictions and encroachments have also aggravated flood conditions throughout the entire city of Danbury. This hazardous condition has become progressively worse over a period of years because of failure to prohibit promiscuous dumping and encroachments by various construction. If a major flood were to occur, under the present conditions of the stream channel, serious damage would occur. The September 1938 flood caused direct damage amounting to $103,600 in the city of Danbury. Almost all of this damage occurred in the zone between the junction of the two tributaries just above Patch Street and the Cross Street bridge, a distance of 2.8 river miles. Topographic surveys, field investigations, and preliminary geologic investigations of this section of the river were made as a basis for cost estimates of the plan of protection. The drainage area in this section varies from 15 square miles at Patch Street to 31 square miles at White Street, and 40 square miles at Cross Street.

b. Plan of improvement. - From a study of the basic data, a plan of protection was chosen which would protect this area against a design flood discharge of 5000 cubic feet per second, which is a reasonable design discharge for the region in which Danbury is located. The largest flood of record was that of September 1938, with an estimated peak discharge of 2500 cubic feet per second. Between Patch Street and the junction of the tributaries above Patch Street, the channel has sufficient capacity, if cleared, and, under the plan considered, all debris and boulders would be removed. From Patch Street to White Street the channel would be rectangular with a bottom width of 30 feet, and low concrete walls would be constructed where necessary to a height sufficient to pass the design flood. From White Street to a point 800 feet above the Chestnut Street bridge, the channel would be rectangular with a bottom width of 65 feet, and concrete walls would be constructed where necessary. From this point to the Cross Street bridge, the channel would have a bottom width of 60 feet, the side slopes would be 1 on 3, and low earth levees would be built along the banks where needed to prevent flooding the overbank areas. New bridges with greater waterway areas would be built at Triangle Street and Casper Street, and one additional 20-foot span would be constructed at the railroad bridge just below White Street. It would be necessary to enlarge the existing channel under White Street to a width of 60 feet. A manually-operated flood gate would be placed on the culvert under the railroad embankment just above Chestnut Street to prevent the area behind the railroad embankment from being flooded by backwater. The bottom of the channel from Patch Street to the point 800 feet above Chestnut Street would be paved with hand-placed riprap. Between this point and a point 1000 feet above the Cross Street bridge, the bottom and side slopes would be paved with hand-placed riprap.

32. <u>WASHINGTON DEPOT, CONNECTICUT.</u>

<u>a.</u> <u>Right bank of the Shepaug River.</u> - The property which would be protected includes the main street of the village of Washington Depot. Included in the area are 20 homes with garages and grounds, a church, seven stores, and a railroad station. Direct losses of $30,900 were sustained in the September 1938 flood when the area was flooded to a depth of one to two feet. Protection could be provided to this area by the construction of an earth levee 800 feet long and 8 feet high, and a concrete wall 1500 feet long and 10 feet high. A pumping station would be required to provide for natural drainage in this area.

<u>b.</u> <u>Left bank of the Shepaug River.</u> - A grade school, high school, and several isolated dwellings are located on the left bank of the Shepaug River in Washington Depot. Damages in this section caused by the September 1938 flood were very slight. Protection to this area could be provided by the construction of an earth levee approximately 1200 feet long and 12 feet high.

APPENDIX D - DETAILS OF DESIGN AND ESTIMATES OF COST

APPENDIX D

DETAILS OF DESIGN AND ESTIMATES OF COST

General

1. SCOPE. - Appendix D describes the design features and presents estimates of cost of the project included in the recommended plan and the Pittsfield channel improvement. The project in the recommended plan is the Thomaston dam and reservoir, located on the Naugatuck River one mile north of Thomaston, Connecticut, as shown on Plate No. 3 of the report.

2. DATA AVAILABLE FOR SURVEY. - Topographic features have been mapped by the plane-table method at the sites of the projects wherever satisfactory information could not be obtained from other sources. Geological investigations consisted of field inspections. In general the existing and supplementary field data give sufficient detail to develop preliminary designs for adequate estimates.

3. BASIS OF ESTIMATES. - The cost of each project has been estimated upon the basis of a preliminary design which will provide an economical and adequate structure for the particular site. Estimates of quantities have been made upon the basis of adopted designs and foundation conditions.

4. UNIT PRICES. - Unit prices are based upon construction costs for similar types of work in New England, particular use being made of cost data from work placed under construction in the Providence District during the past few years. Unit prices vary depending upon the quantities involved, the conditions under which the work would be executed, and the availability and location of the borrow and disposal of materials at each site. The unit prices adopted are adjusted to include numerous minor items of work which do not appear in the cost estimates.

5. CONTINGENCIES, ENGINEERING, AND OVERHEAD. - The construction costs as totaled from the individual items have been increased 20 per-

cent to cover contingencies. This amount is necessary because of the preliminary character of the foundation exploration and the consequent possibility of subsequent design changes and construction difficulties. Engineering and overhead costs are estimated at 15 percent of the resultant construction costs. Estimates for contingencies, engineering, and overhead vary from these percentages only for highway, railroad, and utility relocation, as shown in Paragraph 7 below.

6. RIGHTS-OF-WAY AND DAMAGES. - The costs of rights-of-way and damages which would result from the acquisition of lands and the construction of the projects have been estimated upon the basis of assessed value, field reconnaissance, and information secured from local authorities. Land takings include the sites, adjacent borrow and spoil areas necessary to execute the work, and, in the case of Thomaston Reservoir, will not be overtopped except by floods of very rare occurrence, it is not contemplated that it will be necessary to purchase land lying above the elevation of the spillway crest. Any damage caused by flooding above the spillway crest level can be compensated for by the Federal Government as special damages more economically than by outright purchase of lands. Damages include the severance of lands, and the cost of moving or demolition of existing improvements in the affected area. A factor of 20 percent has been added for the costs of acquisition, including legal cost and general expense. Except for Thomaston Reservoir, local interests will be required to furnish the necessary lands and rights-of-way for all projects and hold and save the United States free from damages due to construction of the projects.

7. HIGHWAY, RAILROAD, AND UTILITY RELOCATION. - The relocations and improvements proposed in this report are planned to conform as nearly as possible to the standards and requirements of the various State highway departments and other interested agencies. Where definite improvements over existing facilities are included, it is antic-

ipated that the Federal Government will be credited with the additional cost of such items. The estimates are generally ample to provide for reasonable modifications. Contingencies on highway, railroad, and utility estimates have been estimated at 15 percent. Engineering and overhead have been estimated at 10 percent for general relocation work and at 15 percent for bridge alterations.

8. BASIS OF ANNUAL COSTS. - Annual costs include interest on the total capital costs, amortization of obsolescence and depreciation, tax losses at 3 percent per annum in Massachusetts and 2-1/2 percent per annum in Connecticut on taxable property purchased for project needs, and maintenance and operation after construction. Interest during construction at 3 percent per annum on one-half the total cost has been added to capital costs wherever the construction period is estimated to require more than one season. Interest on the Federal investment has been computed at 3-1/2 percent and on the non-Federal investment at 4-1/2 percent. Both the Federal and non-Federal investments, except for gates and machinery and bridges, have been amortized over a period of 50 years at the interest rates listed above compounded annually. Gates and machinery have been amortized over a period of 20 years and bridges over a period of 40 years. Maintenance and operation costs are discussed under each of the projects, as are also the distribution of first costs between Federal and non-Federal agencies.

9. DESCRIPTIVE DETAILS OF PROJECTS. - Descriptions of the projects, together with pertinent facts, are briefly set forth in the following paragraphs.

Thomaston Reservoir

10. GENERAL. - The Thomaston Reservoir, on the Naugatuck River 30.0 miles above its confluence with the Housatonic River, is outlined on Plate No. 1, appendix D. The dam site is located 1.1 miles north of Thomaston, Connecticut. The reservoir will extend upstream a distance

of 6.4 miles and will lie in the towns of Harwinton, Plymouth, Litchfield, and Thomaston in Litchfield County. The 97 square miles of drainage area are mostly hilly and woodland. The proposed reservoir will provide storage capacity for 8.0 inches of run-off from the drainage area above, or 41,500 acre-feet, at the spillway crest elevation of 486.0 feet above mean sea level. At this elevation the reservoir will occupy 910 acres of land, including 34 sets of buildings and the sites of two abandoned dams. The area to be occupied is classified as follows:

a. Agricultural land . . . . 450 acres

b. Wooded land . . . . 320 acres

c. Swamp land. . . . . 140 acres

d. Towns, etc. 0

11. HIGHWAYS AND ROADS. - State Highway No. 8, a two-lane concrete road with a bituminous surface treatment, lies within the reservoir area for a distance of 5.4 miles and requires relocation. It is proposed to improve an existing highway on the west side of the reservoir from Thomaston to Campville. A reservoir crossing will be provided at Campville and the relocation continued on the east side of the reservoir to a point in the present line of State Highway No. 8, which is above the proposed spillway crest. The tentative relocation is shown on Plate No. 1, appendix D.

12. RAILROADS. - The Waterbury and Winsted Branch, a single track line, of the New York, New Haven and Hartford Railroad lies within the reservoir area for a distance of 5.4 miles. It is proposed to relocate this track on the east side of the reservoir for a distance of 8.0 miles, beginning at a point below Thomaston and continuing to a point on the existing track which is 5 feet above the elevation of the proposed spillway. The tentative relocation is shown on Plate No. 1, appendix D.

13. OTHER PUBLIC UTILITIES. - A total of 6 miles of telephone and electric distribution lines will be relocated.

14. DAM. - A general design of the proposed dam, the area and capacity curves, and the geologic features are indicated on Plates Nos. 1 and 2, appendix D.

a. Geology. - The valley side, forming the right abutment, is made up of inclined schist strata. Outcrops of similar rock occur at the river about 400 feet upstream, and in rounded hogback formations in the valley bottom on the left side. Rock in the hillside forming the left abutment is estimated to occur at shallow depth up to elevation 515, where ledge rock is exposed at the surface. The spillway and discharge tunnel will be constructed in rock on the right bank.

b. Available Materials. - Pervious materials, sand and gravel, may be obtained upstream within 1 mile, and impervious materials, a mixture of sand, silt, and gravel, likewise upstream within 1.5 miles. Local sand and gravel deposits are of unsuitable quality for use in concrete construction. The use of commercial concrete aggregates is proposed.

c. Dam and appurtenant works. - A rolled-earth and rock fill dam across the main channel is proposed, with a side-channel spillway cut out of rock in the right bank 50 feet beyond the end of the dam. The length of the dam will be 1,423 feet and the elevation of the top will be 506.0 feet above mean sea level. The top will be 136 feet above the bed of the stream, allowing a freeboard of 5 feet above the spillway design flood surcharge. The outlet will consist of a gate-controlled tunnel discharging into the Naugatuck River.

d. Embankment. - The dam will have a top width of 30 feet. It will contain a central core of impervious materials, keyed into rock along the axis of the dam. The core will be backed by a pervious section on both upstream and downstream faces, and the outside slopes of the dam will be 1 on 3 from the bottom to within 20 feet of the top, the upper 20 feet having side slopes of 1 on 2-1/2. Sufficient rock will be available from spillway and outlet excavations to provide a heavy facing on both slopes of the dam.

e. Spillway. - A side-channel spillway, having a permanent crest 486.0 feet above mean sea level and 290 feet long, will be built into the ledge rock of the right abutment. This spillway, the trough section of which will be concrete-lined, will discharge into a retreat channel, returning to the river 325 feet below the toe of the dam. The discharge capacity under a surcharge of 15 feet will be 63,800 cubic feet per second, or 655 cubic feet per second per square mile. A concrete retaining wall will be placed along the left side of the spillway to protect the downstream toe of the dam. The discharge capacity was determined as fulfilling the following requirement of operation during the spillway design flood.

(1) Spillway requirements. - The spillway of the Thomaston Reservoir shall have sufficient capacity to pass the spillway design flood with no possibility of overtopping the dam, even under the following adverse conditions:

(a) The reservoir filled to spillway crest at the beginning of the spillway design flood.

(b) The outlet gates closed.

(c) The outlet gates inoperative, or the outlet passages blocked during the entire flood period.

(d) The maximum wave height occurring at the instant of maximum spillway discharge.

(2) Spillway design flood. - The spillway design flood for the Thomaston Reservoir is based upon the following conditions:

(a) The use of a unit graph determined from floods of record at the United States Geological Survey gaging station on the Naugatuck River near Thomaston, plus the unit graph at the United States Geological Survey gaging station on Leadmine Brook near Thomaston, corrected for drainage area.

(b) A rainfall volume and distribution as recently determined by the Office of the Chief of Engineers, based upon a recent study of rainfall in New England.

(c) A rainfall duration of twenty-four hours.

(d) An infiltration rate of 0.05 inch per hour.

(e) A factor of safety of 1.25 applied to the computed flood.

The computed flood without the factor of safety results from the worst possible storm magnitude, intensity, distribution, rate of infiltration, and watershed run-off conditions. Because of the smaller maximum rainfall rates to be expected in winter, the computed flood described is more severe than the corresponding computed winter flood, including run-off from melting snow. It was assumed that the effect of surcharge storage would offset the loss of valley storage. The resulting maximum spillway discharge is 63,800 cubic feet per second. A freeboard of 5 feet will be provided above the maximum surcharge elevation. Data and characteristics pertaining to the spillway as designed are given in the following table:

TABLE I - APPENDIX D

THOMASTON RESERVOIR

SPILLWAY DATA AND CHARACTERISTICS

Gross drainage area in square miles	97
Reservoir capacity at spillway crest	
Acre-feet	41,500
Inches of run-off	8.0
Elevations, feet above mean sea level	
Spillway crest	486.0
Top of dam	506.0
Spillway	
Type	Side-channel
Location	In right abutment
Discharge coefficient	3.8
Design discharge in cubic feet per second	63,800
Surcharge in feet	15.0
Crest length in feet	290

f. Outlet. - A concrete-lined tunnel 765 feet long will provide for stream diversion during the construction of the embankment and finally for reservoir control. The cross section will be of horseshoe shape, with a diameter of 15.0 feet and a net area of 186.6 square feet. The capacity under maximum head with the reservoir level at spillway crest will be 10,200 cubic feet per second. The tunnel will discharge into the river channel 170 feet below the toe of the dam. The control will consist of three Broome sluice gates, each 6.0 feet by 12.0 feet, mechanically operated from a gate house above the tunnel entrance. A service bridge from the top of the dam to the gate house will be provided. The following procedure was used in determining a satisfactory design for the gate-controlled outlet:

(1) The outlet design flood was selected as an hypothetical flood with a volume equal to the volume of run-off of 100-year frequency on a stream of equal drainage area in New England with a triangular distribution over a 2-1/2-day period. The unit graph used is described under the description of the spillway design flood.

(2) A retarding basin discharge was computed such that, with all gates open, the pool elevation would reach, but not exceed, the spillway crest.

(3) This discharge was increased by a flexibility factor of 1.5 in order to provide flexibility of operation to obtain the greatest flood reductions at downstream damage centers.

(4) The outlet was designed to pass at least the retarding basin discharge increased by this flexibility factor.

(5) It was necessary to increase this design discharge capacity to allow:

  (a) Passing of local freshets that would not produce damage without utilizing more than a minor portion of the flood control capacity of the reservoir.

  (b) Emptying a full reservoir within a period of a few days.

  (c) Passing possible minor floods during construction of the dam with upstream levels that would not require an excessive height of cofferdam.

(6) The size of the outlet was not considered as affecting the safety of the dam against overtopping, because in determining the size of the spillway no outlet discharge is assumed.

The retarding basin discharge for Thomaston Reservoir, increased by the flexibility factor, is 1,800 cubic feet per second. It was necessary to increase this discharge to allow for diversion during construction. Data and characteristics pertaining to the outlet as designed are given in the following table.

TABLE II - APPENDIX D

THOMASTON RESERVOIR

OUTLET DATA AND CHARACTERISTICS

Gross drainage area in square miles	97
Reservoir capacity at spillway crest	
Acre-feet	41,500
Inches of run-off	8.0
Elevations, feet above mean sea level	
Spillway crest	486.0
Outlet invert at intake	376.0
Outlet invert at exit	375.0
Outlet crown at exit	390.0
Maximum operating head in feet	96.0
Conduit length in feet	790
Loss in terms of velocity head in feet	2.05
Maximum velocity, feet per second	54.9
Maximum retarding basin discharge in cubic feet per second	1200
Factor of flexibility	1.5
Design discharge, reservoir pool at spillway crest	
Cubic feet per second	1800
Cubic feet per second per square mile	18.5
Service gates	
Type	Broome
Number	3
Size in feet	6.0 x 12.0
Conduit	
Type	Horseshoe
Number	1
Diameter in feet	15.0
Area in square feet	186.6
Maximum discharge in cubic feet per second	10,200

g. Plan of construction. - Work will begin on the outlet works upon completion of a temporary detour of the existing State highway. The relocation of both the highway and the railroad, the driving of the outlet tunnel, and the partial preparation of the foundation of the dam will be carried on concurrently. Stream flow will be diverted through the outlet tunnel upon its completion and the placing of the embankment and excavation of the spillway will progress. Finally the concrete for the spillway structure will be placed. The time estimated for construction is two years.

h. Estimate of cost. - The estimated costs of the Thomaston Reservoir are given in the following table:

TABLE III - APPENDIX D
COST ESTIMATE OF THOMASTON RESERVOIR

Item No.	Item	Quantity	Unit	Unit cost	Cost	Total cost
1	Construction					
	Clearing			Lump sum $	22,000	
	Stream control			Lump sum	10,000	
	Earth excavation, common	83,000	cu.yd.	.40	33,000	
	Earth excavation, borrow	1,500,000	cu.yd.	.35	525,000	
	Rock excavation, open cut. . . .	210,000	cu.yd.	2.00	420,000	
	Rock excavation, tunnel or shaft	7,600	cu.yd.	10.00	76,000	
	Embankment, rolled	1,550,000	cu.yd.	.10	155,000	
	Dumped rock	300,000	cu.yd.	.50	150,000	
	Riprap, hand-placed.	5,000	cu.yd.	3.50	17,000	
	Concrete, plain.	5,600	cu.yd.	12.00	67,000	
	Concrete, reinforced	8,600	cu.yd.	16.00	138,000	
	Reinforcement steel.	443,000	lb.	.05	22,000	
	Gates and machinery.			Lump sum	100,000	
	Gatehouse and miscellaneous.			Lump sum	72,000	
	Bridges, service and road.			Lump sum	38,000	
					1,845,000	
	Contingencies			20%	369,000	
					2,214,000	
	Engineering and overhead			15%	332,000	
	TOTAL					$2,546,000
2	Relocation of railroads and utilities					
	N.Y., N.H. & H. single track . .	8.0	mi.	Lump sum	1,150,000	
	Structures			Lump sum	335,000	
	Telephone & electric dist. lines	9.0	mi.	Lump sum	9,000	
					1,494,000	
	Contingencies			15%	224,000	
					1,718,000	
	Engineering and overhead			10%	172,000	
	TOTAL					1,890,000
3	Rights of way and land					
	Land	990	acres	Lump sum	66,000	
	Buildings purchased	34	sets	Lump sum	151,000	
					217,000	
	Legal, overhead, and general expenses.			20%	43,000	
	TOTAL					260,000
4	Highway relocation					
	Improve existing highway	3.5	mi.	Lump sum	105,000	
	Relocate 20-ft bit. macadam. . .	2.8	mi.	Lump sum	168,000	
	Structure			Lump sum	87,000	
					360,000	
	Contingencies.			15%	54,000	
					414,000	
	Engineering and overhead			10%	41,000	
	TOTAL					455,000
5	Grand total capital cost					5,151,000

i. Annual costs. - Annual charges are computed upon the basis that the Federal Government will bear all costs and maintenance of the project. Annual maintenance expenses include a lump sum of $3,000 for the dam, 3 percent of the cost of gates and machinery, and 1 percent of the cost of concrete structures. Operation charges include an operator at $1,500 per annum and $500 for expendable supplies, stand-by power, etc. A general overhead charge of $3,000 has been assessed to the project. The estimated annual costs of the Thomaston Reservoir, computed upon this basis, are given in the following table.

TABLE IV - APPENDIX D

ESTIMATED ANNUAL COSTS OF THOMASTON RESERVOIR

Item No.	Item	Cost	Total cost
1	Federal investment		
	Grand total capital cost (Item 5).	$5,151,000	
	Interest during construction (5,151,000 x 0.03)	155,000	
	TOTAL (Federal investment)	5,306,000	
2	Federal annual charges		
	Interest . . . .(5,306,000 x 0.035)	185,700	
	Amortization of obsolescence and depreciation		
	Earthwork and general (1.38 x 1.03 x .0076 x 1,518,000)	16,400	
	Concrete . . . . . . (1.38 x 1.03 x .0076 x 227,000)	2,500	
	Gates and machinery (1.38 x 1.03 x .0354 x 100,000)	5,000	
	Railroads and utilities(1.265 x 1.03 x .0076 x 1,494,000)	14,800	
	Rights of way and land(1.20 x 1.03 x .0076 x 216,000)	2,000	
	Highways . . . . . . (1.265 x 1.03 x .0076 x 360,000)	3,600	
	Maintenance and operation		
	Embankment and general overhead	6,000	
	Operator and expendable supplies	2,000	
	Concrete . . . . (1.38 x 0.01 x 227,000)	3,100	
	Gates and machinery. . . . . . (1.38 x 0.03 x 100,000)	4,100	
	TOTAL (Federal annual charges)		$245,200
3	Non-Federal investment	None	
4	Non-Federal annual charges		
	Tax loss on land . . . . ($216,000 x .025)	5,400	
	TOTAL (non-Federal annual charges)		5,400
	TOTAL ANNUAL COST (2+4)		250,600

Pittsfield Channel Improvement

15. GENERAL. - Plan III for the channel improvement on the Housatonic River in Pittsfield would provide complete flood protection to the portion of the city within 9,500 feet above Van Sickler Dam against a flood discharge of 3,400 cubic feet per second, which is equal to the greatest flood of record, that of September 1938. Plates Nos. 3 and 4, appendix D, show plan, profiles for existing and improved conditions, cross sections, bridges, and sewer crossings.

16. FLOOD LOSSES. - On the Housatonic River in Pittsfield, a residential section of about 100 houses, known as "Lakewood", is subject to frequent flooding of basements and a few first floors. Other properties nearby which have been damaged include the extensive plant of the General Electric Company, the city electric plant, several small industries, and some residential and commercial property in the vicinity of Silver Lake. The flood of September 1938 caused shallow flooding of this area and damage in house cellars or plant basements and boiler rooms. Direct losses totaled $39,000. The flood of March 1936 also caused damage of approximately the same amount.

17. GEOLOGY. - The river has built a flood plain of silty sand over which it is meandering. Much of the land near the present stream is artificially filled. Below Newell Street the natural overburden is an alluvial deposit of fine sand and silt. Above this point, the right bank of the river is made up of a sandy reworked glacial formation, containing gravel and cobbles, while the material on the left bank is alluvial sand. No rock is present in or near the stream.

18. CHANNEL EXCAVATION. - The proposed channel improvement would provide a uniform channel section and straighten the alinement from Elm Street to a point 800 feet above Longview Terrace footbridge, and in addition would include clearing and grading the existing channel section below Elm Street for a distance of 700 feet. The total length of the improved channel would be 8500 feet or 3000 feet less than the present

length of channel between the limits of the improvement. The plan, profile, and representative sections are shown on Plate No. 4, appendix D. The proposed channel section would have a bottom width of 50 feet and side slopes of 1 vertical on 2 horizontal except for a length of 1200 feet above Newell Street. Restrictions caused by urban developments on both banks in the latter reach of channel would necessitate the use of a steeper side slope of 1 on 1-1/2, but the equivalent area at a water depth of 13 feet would be obtained by increasing the bottom width to 56 feet. A retaining wall 100 feet in length would protect the rear of residences fronting Parkside Avenue in the vicinity of Richardson Street. Riprap would be placed on the banks of the channel to protect them against erosion by velocities estimated to range from 4 to 6 feet per second. The quantity of channel excavation is estimated at 180,000 cubic yards and would be disposed of in graded levees along the channel to restrict the extent of overbank flooding.

19. BRIDGES. - The proposed channel improvement would necessitate increased channel capacities under two existing bridges across the present channel. These would be provided in the following manner.

a. Longview Terrace footbridge. - It is proposed to move the existing 75-foot truss bridge a distance of 45 feet to the north of its present location and place it on new abutments 1 foot higher than its present elevation, and add a 15-foot I-beam span to each end. No appreciable amount of approach work would be required.

b. Lyman Street bridge. - The existing 73.5-foot span plate girder bridge would be raised a height of 1-1/2 feet on its present abutments. Suitable approach grades would be provided.

Sections of the proposed bridge changes are shown on Plate No. 4, appendix D.

20. ALTERATIONS TO EXISTING SEWER SYSTEMS. - The proposed change in channel alinement would necessitate extending and constructing outlets for existing storm-water drains now discharging into the channel. Also,

the grades of trunk sewers at three river crossings would have to be lowered to allow an unobstructed flow in the proposed channel.

21. PLAN OF CONSTRUCTION. - Alterations to bridges, sewer crossings, and drains would be made prior to excavation of the channel. Removal of material, grading of slopes, and placing of riprap would be limited to one side of the channel at a time, except in cut-off areas, to allow passage of normal flow at all times. The time required for the construction of the channel is estimated to be one season.

22. ESTIMATE OF COST. - The estimated costs of the Pittsfield Channel Improvement are given in the following table:

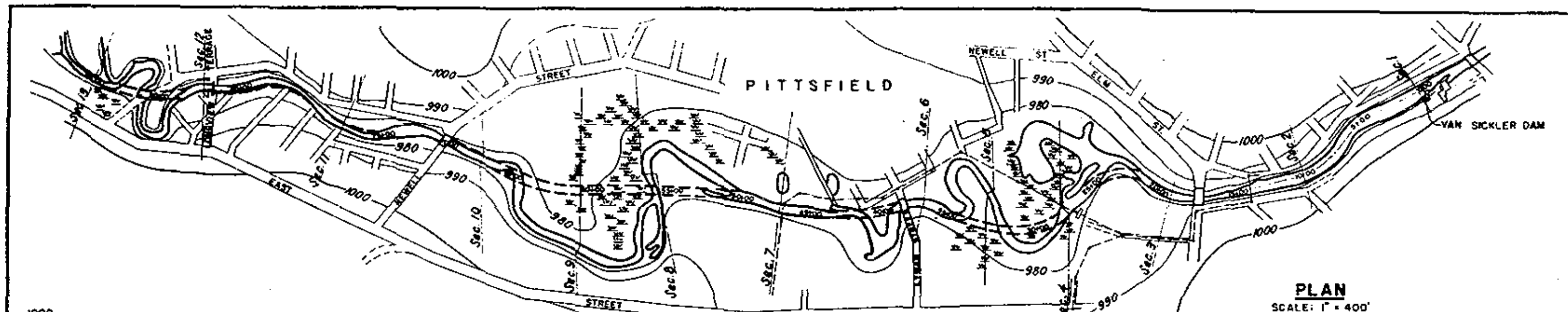
TABLE V - APPENDIX D
COST ESTIMATE OF PITTSFIELD CHANNEL IMPROVEMENT

Item No.	Item	Quantity	Unit	Unit cost	Cost	Total cost
1	Channel excavation					
	Clearing	16	acres	$200.00	$ 3,200	
	Stream control			Lump sum	10,000	
	Channel excavation	180,000	cu.yd.	.50	90,000	
	Riprap, hand-placed	28,000	cu.yd.	5.00	140,000	
	Concrete, Class B	150	cu.yd.	12.00	1,800	
	Excavation and backfill. . .	250	cu.yd.	.40	100	
					245,100	
	Contingencies			20%	49,000	
					294,100	
	Engineering and overhead			15%	43,900	
	TOTAL					$338,000
2	Alterations to existing sewer system					
	River crossings	3		Lump sum	24,000	
	Extension of drains.			Lump sum	11,000	
					35,000	
	Contingencies			20%	7,000	
					42,000	
	Engineering and overhead			15%	6,000	
	TOTAL					48,000
3	Bridges					
	Longview Terrace (footbridge).			Lump sum	5,000	
	Lyman Street			Lump sum	4,000	
					9,000	
	Contingencies.			15%	1,400	
					10,400	
	Engineering and overhead			15%	1,600	
	TOTAL					12,000
4	Rights-of-way and damages					
	Land and damages			Lump sum	16,000	
					16,000	
	Overhead, legal, and general expense			20%	3,000	
	TOTAL					19,000
5	Grand total capital cost					417,000

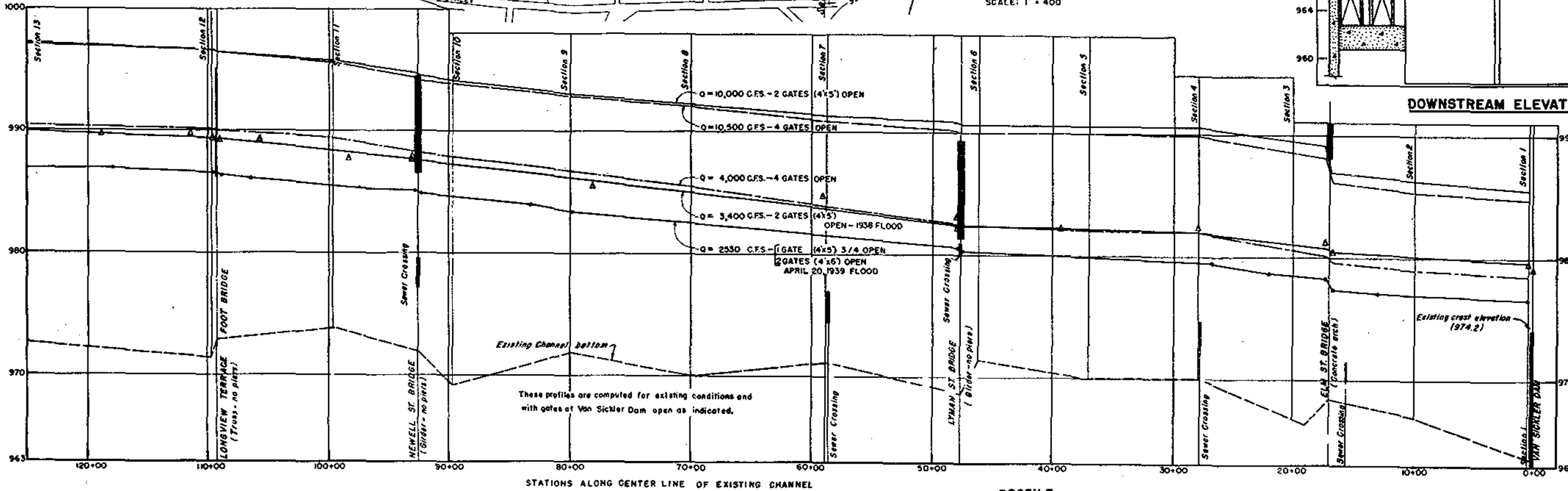
23. ANNUAL COSTS. - Annual costs are computed upon the basis that the Federal Government would pay for the cost of channel construction and that all other costs, including maintenance, would be paid by non-Federal agencies. Annual maintenance includes $700 for the channel, one percent of the cost of sewer crossings, and a charge of $500 for local overhead costs. The estimated annual costs for the Pittsfield Channel Improvement are given in the following table:

TABLE VI - APPENDIX D
ESTIMATED ANNUAL COSTS OF PITTSFIELD CHANNEL IMPROVEMENT

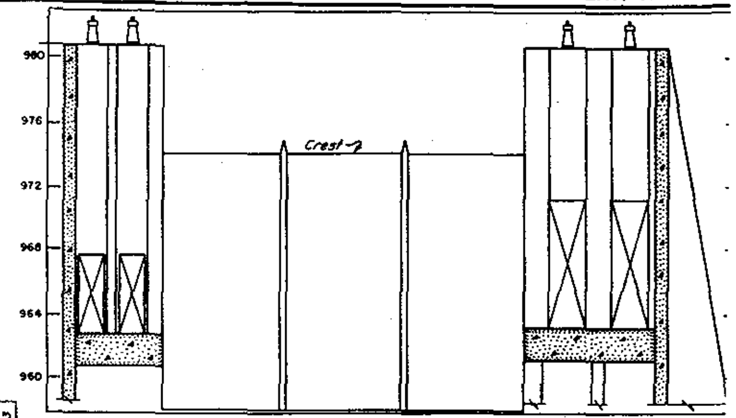
Item No.	Item	Cost	Total cost
1	Federal investment		
	Channel excavation	338,000	
	TOTAL (Federal investment)	$ 338,000	
2	Federal annual charges		
	Interest (338,000 x .035)	11,830	
	Amortization of obsolescence and depreciation		
	Channel excavation (245,100 x 1.38 x .0076)	2,570	
	TOTAL (Federal annual charges)		$ 14,400
3	Non-Federal investment		
	Alterations to existing sewer system	48,000	
	Bridges	12,000	
	Rights-of-way and damages	19,000	
	TOTAL (non-Federal investment)	79,000	
4	Non-Federal annual charges		
	Interest (79,000 x .045)	3,560	
	Amortization of obsolescence and depreciation		
	Sewers (35,000 x 1.38 x .0056)	270	
	Bridges (9,000 x 1.32 x .0093)	110	
	Land and damages (16,000 x 1.20 x .0056)	110	
	Tax loss (16,000 x .03)	480	
	Maintenance and operation		
	Channel Lump sum	700	
	Sewers (24,000 x 1.38 x .01)	330	
	Overhead Lump sum	500	
	TOTAL (non-Federal annual charges)		6,060
5	TOTAL ANNUAL COST (2 + 4)		20,460



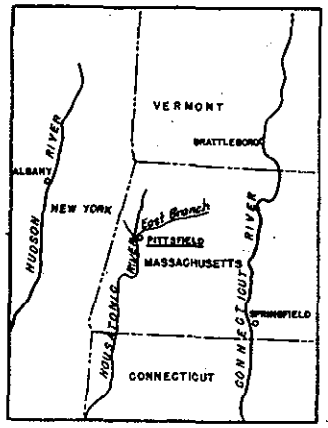
PLAN
SCALE: 1" = 400'



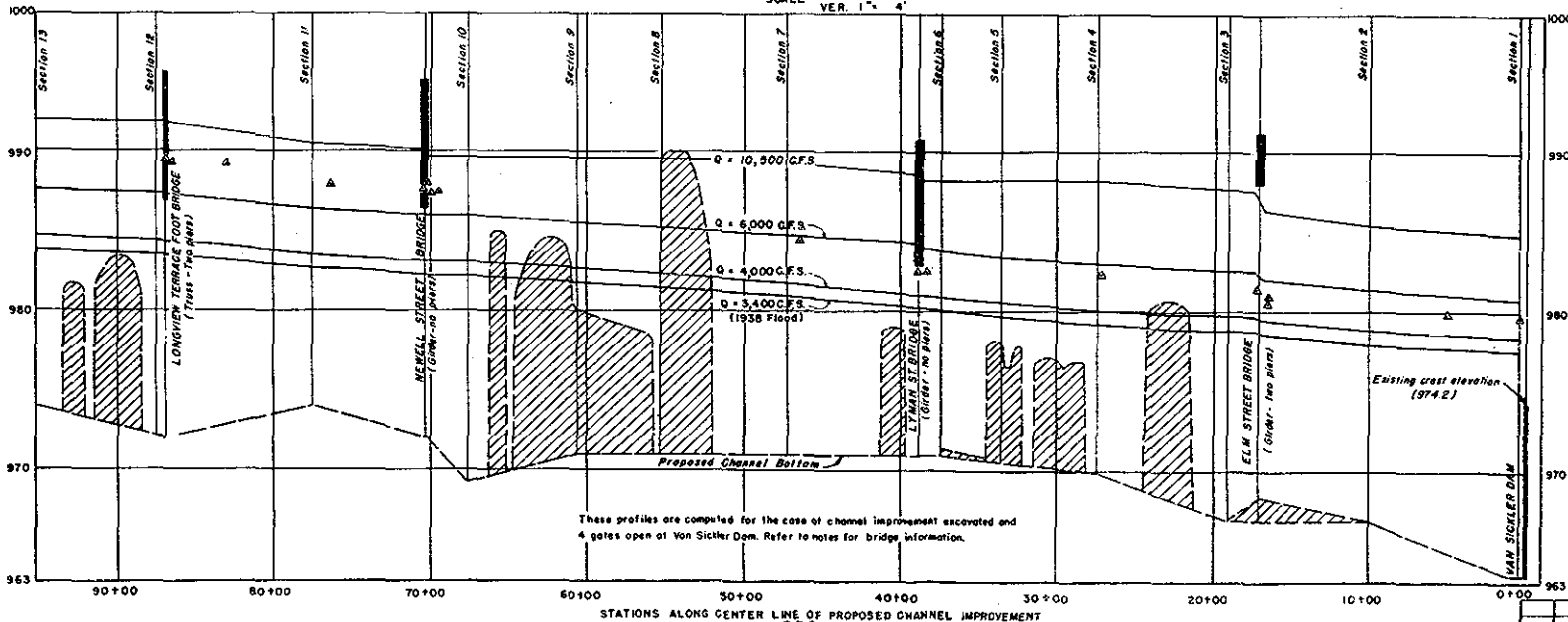
PROFILE



DOWNSTREAM ELEVATION OF VAN SICKLER DAM
SCALE: HOR. 1" = 10' VERT. 1" = 4'



LOCATION MAP



PROFILE

LEGEND

△ Indicates September 1938 High-Water marks.
⊙ Indicates April 20, 1939 High-Water marks.
▨ Indicates proposed excavation

NOTES:

Elevations refer to Mean Sea Level Datum.

Plan prepared by the City of Pittsfield, Mass., October 193

Cross sections taken by U.S.E.D. April 1939.

Sewer crossings for proposed plan are assumed to be inverted siphons two feet under channel bottom.

Gates at Van Sickler Dam consist of 2 at 4'x 5' and 2 at 6'x 8'.

Lyman Street bridge is raised 18".

Longview Terrace bridge is moved and raised one foot.

Existing bridges at Elm Street and Newell Street are satisfactory.

Refer to Plate No.4 Appendix D for cross section.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

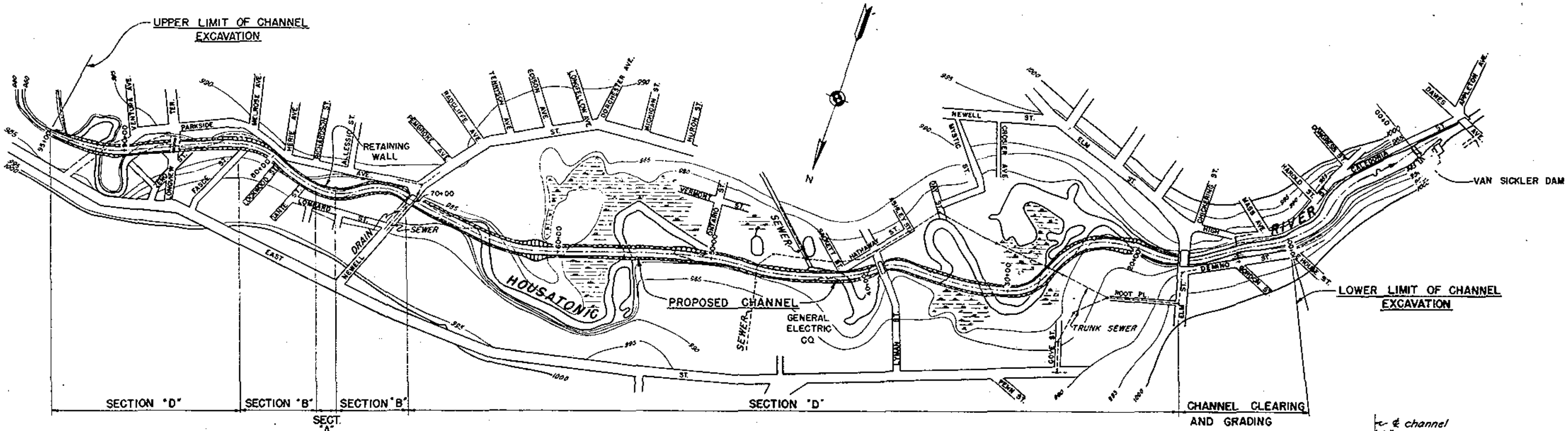
HOUSATONIC RIVER FLOOD CONTROL
PITTSFIELD CHANNEL IMPROVEMENT
PLAN AND PROFILES

HOUSATONIC RIVER — MASSACHUSETT
IN 2 SHEETS — SCALE: 1 IN. = 400 FT. — SHEET NO. 1

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., JUNE 194

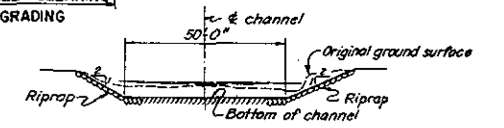
SUBMITTED: John B. Drisko, ENGINEER, HEAD, HYDRAULICS SECTION
APPROVAL RECOMMENDED: [signature], PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV
APPROVED: [signature], LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

COMPILED BY [signature], ASSOC. ENGINEER
DRAWN F.C.T. TRACED: K.N.W. CHECKED: [signature]
TO ACCOMPANY REPORT DATED: JUNE 20, 1940
FILE NO. HC-3-1004



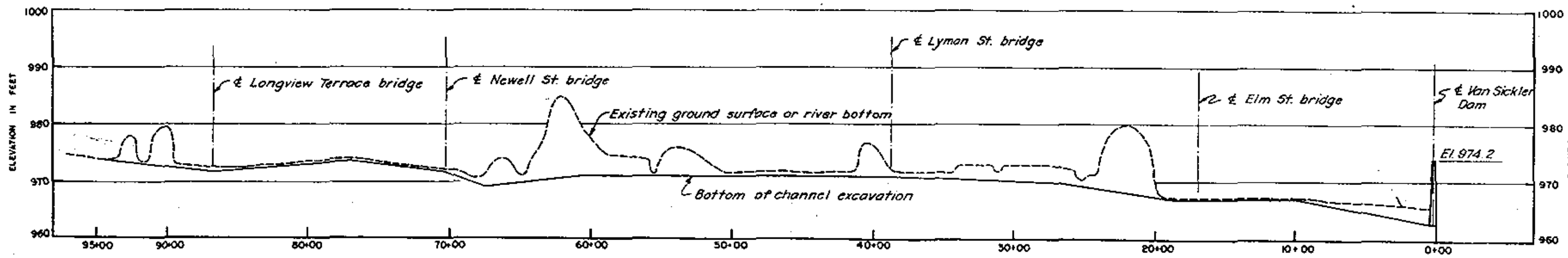
PLAN

SCALE: 1"=300'-0"



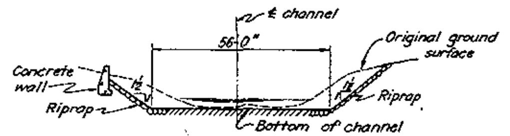
SECTION "D"

SCALE: 1"=20'-0"



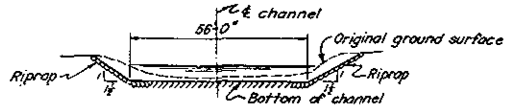
PROFILE ALONG ℄ CHANNEL

SCALES: HOR. 1"=400'-0" VERT. 1"=10'-0"



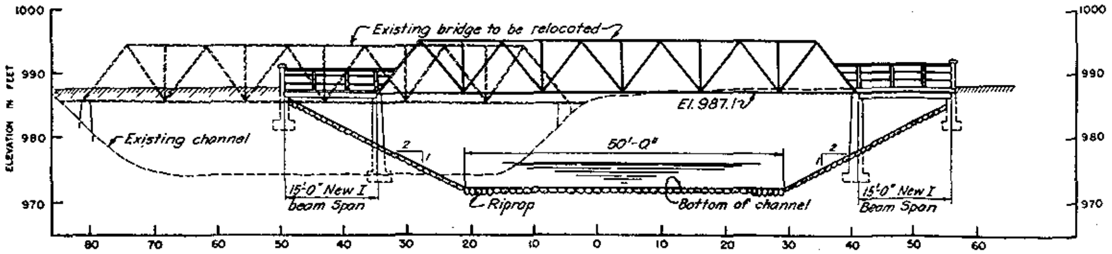
SECTION "A"

SCALE: 1"=20'-0"



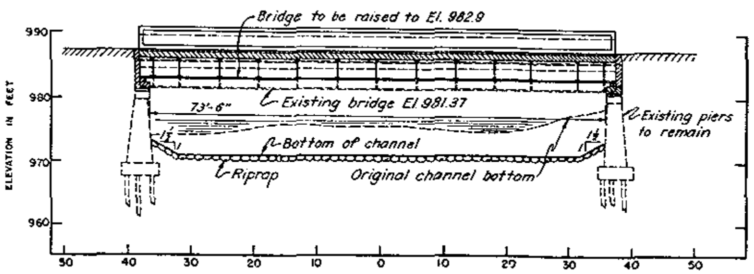
SECTION "B"

SCALE: 1"=20'-0"



LONGVIEW TERRACE FOOT BRIDGE

SCALE: 1"=10'-0"



LYMAN ST. BRIDGE

SCALE: 1"=10'-0"

NOTES

Elevations refer to Mean Sea Level Datum.
For location of project see Plate No. 1 of report.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

HOUSATONIC RIVER FLOOD CONTROL

PITTSFIELD CHANNEL IMPROVEMENT

GENERAL PLAN

HOUSATONIC RIVER — MASSACHUSETTS

IN 2 SHEETS — SCALE: 1 IN.=300 FT. — SHEET NO. 2

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., JUNE 194

SUBMITTED: SENIOR ENGINEER, HEAD, DESIGN SECTION
APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV.
APPROVED: LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED: ASST. ENGINEER
DRAWN: J.S.
TRACED: M.B.R.
CHECKED:

TO ACCOMPANY REPORT DATED: JUNE 20, 1940
FILE NO. HC-3-1007

APPENDIX E - POLLUTION

APPENDIX E - POLLUTION

General

1. INTRODUCTION. - Abatement of pollution in the Housatonic Watershed may be considered a twofold problem. Along the main river and its tributaries in the northern and western portions of the basin, the aim is to insure clean streams suitable for the full recreational development of the region. Present industrial needs dictate a lesser degree of purification of the heavily polluted Naugatuck River. This stream, according to State authorities, is the most grossly contaminated waterway in Connecticut. Except for cities along the lower Naugatuck River, nearly all population concentrations are served by sewage-disposal plants. Most of these furnish complete treatment. The trade waste problem is serious along the Naugatuck River, but relatively minor elsewhere in the watershed. Since the main river is an interstate stream, complete pollution control must depend upon cooperation between Massachusetts and Connecticut.

2. SCOPE. - This appendix describes the general sanitary conditions along the various streams in the Housatonic River Watershed; states the sources, types, and quantities of polluting substances; and lists the remedial measures now in operation, under construction, or proposed. Studies were made of existing and proposed pollution control legislation, water analyses, and reports prepared by other agencies, particularly those of the Massachusetts Department of Public Health and the Connecticut State Water Commission. Conferences and interviews with State officials furnished the information needed for bringing published data up to date. Flood control works, proposed in the main body of this report, and conservation storage are discussed with regard to their effects upon pollution problems.

3. PREVIOUS REPORTS. - Preparation of pollution studies for the Housatonic Basin was facilitated by the several recent reports made

available by State agencies and the New England Regional Planning Commission. Under sponsorship of the Massachusetts Department of Public Health, a report[1] on pollution in that State's portion of the Housatonic River Valley was prepared in September 1936 by the Works Progress Administration. Other information on sanitary conditions in the Massachusetts portion of the watershed was obtained from State Senate No. 50[2] of 1937 and House No. 1735[3] of 1938. The largest watershed area of the basin lies in Connecticut, its pollution sources being adequately described in the State Water Commission's "Watershed Pollution Study" report[4] of 1934. Supplementary information regarding the trend of developments in Connecticut was obtained from the biennial reports[5] of the State Water Commission for the periods ending 1932, 1934, 1936, and 1938. While no printed reports were available for the area in New York State, data were furnished by the State Department of Health. Other reports used include the annual reports of the Massachusetts and Connecticut State health departments.[6,7] Footnote numbers in this appendix refer to corresponding listings in the bibliography on page 113.

4. DESCRIPTION OF THE BASIN. - The location, size, topography, and general characteristics of the main stream and its tributaries are fully described in paragraphs 7 to 11 of the main report. Description of the sanitary condition of the various streams of the basin follows in paragraphs 16 to 20 of this appendix.

5. POPULATION. - Latest estimates indicate the present population of the watershed exceeds 400,000, with most of the increase since 1930 traceable to growth in the industrial communities. Information derived from 1930 Federal Census figures, in paragraph 13 of the main report, shows that population densities in the Massachusetts and New York portions of the basin are only one-third as high as state-wide figures, whereas the Connecticut area is two-thirds as densely settled

as the entire State. Population is concentrated in two zones, the heavier in the Naugatuck Valley and the other along the upper reaches of the Housatonic River near Pittsfield. There is little intermediate population gradation between the cities and the sparsely settled areas along the main river in Connecticut. The recreational importance of the western and northern sections of the watershed results in large seasonal population increases, most noticeable during the summer months in the Berkshire Hills region. Of the numerous relationships which may be drawn between population and stream pollution, most evident is the fact that the more heavily populated towns have the more urgent and complicated problems of waste disposal. All 18 of the cities with populations exceeding 3000, listed in paragraph 13 of the report, have sewerage facilities, but relatively few have modern sewage-disposal plants. Pollution of the natural waterways by sewage results. Waterway pollution is directly proportional to population density. The results of heavy population, with lack of waste treatment facilities, are evident in the lower Naugatuck Valley. Pollution emanating from the cities along the upper Housatonic River in Massachusetts is not noticeable along the lower river because of the self-purification attained in the lengthy unpopulated reach from Great Barrington, Massachusetts, to Shelton, Connecticut. Other lesser populated zones are well-spaced along the river so that their residual effect is lessened through self-purification by aeration and sedimentation. At sewered communities decomposition and oxidation of wastes is greater when sewage is being discharged through several small outlets than when it flows from one large outfall. Small individual discharges also result in less objectionable local conditions at the outfalls.

Laws and Activities

6. POLLUTION LAWS. - The Housatonic River Watershed, including areas in three States and containing a navigable waterway, is subject to several pollution abatement laws, both Federal and State. To prevent contamination of potable waters, the watersheds and streams preempted for municipal water supply are safeguarded by the rigid enforcement of State public health laws. The general statutes in effect are outlined in the following paragraphs on pollution legislation.

a. Federal. - The 13.5-mile, navigable portion of the Housatonic River, from Long Island Sound to Shelton, is directly subject to Federal navigation laws, whereas other portions of the watershed are only indirectly concerned with provisions of the "Laws for the Protection and Preservation of the Navigable Waters of the United States" as embodied in the River and Harbor Act approved March 3, 1899. Section 13 of this law makes it illegal to discharge

> "either from or out of any ship, barge, or other floating craft of any kind, or from the shore, wharf, manufacturing establishment, or mill of any kind, any refuse matter of any kind or description whatever other than that flowing from streets and sewers and passing therefrom in a liquid state, into any navigable water of the United States, or into any tributary of any navigable water from which the same shall float or be washed into such navigable water; and it shall not be lawful to deposit, or cause, suffer, or procure to be deposited material of any kind in any place on the bank of any navigable water, or on the bank of any tributary of any navigable water, where the same shall be liable to be washed into such navigable water, either by ordinary or high tides, or by storms or floods, or otherwise, whereby navigation shall or may be impeded or obstructed . . ."

b. State.

(1) Massachusetts. - There is no law in Massachusetts by which the State can order abatement of pollution, except that caused by oil or that resulting in a definite health menace. The State Department of Public Health is the agency charged with pollution control responsibility. Chapter 111, Section 17, of the Massachusetts General Laws, as amended in 1937, follows:

"The department (of Public Health) shall consult with and advise the officers of towns and persons having or about to have systems of . . . sewerage, . . . as to the best method of disposing of their . . . sewage with reference to the existing and future needs of other towns or persons which may be affected thereby. It shall also consult with and advise persons engaged or intending to engage in any manufacturing or other business whose . . . sewage may tend to pollute any inland water as to the best method of preventing such pollution, and it may conduct experiments to determine the best methods of the purification or disposal of . . . sewage. No person shall be required to bear the expense of such consultations, advice or experiments. Towns and persons shall submit to said department for its advice and approval their proposed system of . . . the disposal of . . . sewage, and no such system shall be established without such approval. All petitions to the general court for authority to introduce a system of . . . sewerage shall be accompanied by a copy of the recommendation, advice and approval of said department thereon. The department may after a public hearing require a city or town . . . to make such improvements relative to any existing treatment works as in its judgment may be necessary for the protection of the public health. In this section the term 'sewage' means domestic and manufacturing filth and refuse."

Study of this statute reveals that a city or town, although fully aware of the urgent need of a system of collecting-sewers or a treatment plant, is under no compulsion to construct any works. If they are to be constructed, plans must be approved by the Department of Public Health. However, once such a plant is in operation, the Department has authority to compel improvements or enlargements to be made if the desired degree of purification is not being provided.

(2) New York. - The 215 square miles of the watershed area, drained by the Green and Tenmile Rivers in New York, are governed by the stringent public health laws of that State. Chapter 45, article 3, section 76 of the consolidated laws states:

"No person, corporation or municipality, shall . . . discharge . . . into any of the waters of this state, in quantities injurious to the public health, any sewage, garbage, offal, or any decomposable or putrescible matter of any kind or the effluent from any sewage disposal plant, or any substance, chemical or otherwise, or any refuse or waste matter, either solid or liquid, from any sewer or drainage system, or from any shop, factory, mill, or industrial establishment; unless express permission to do so shall have been first given in writing by the state commissioner of health . . . But this section shall not prevent the discharge of sewage from any public sewer system owned and maintained by a municipality until an order prohibiting same shall be made . . . , or the discharge of refuse or waste matter from any shop, factory, mill or industrial establishment, if such sewer system was in operation and was discharging sewage, or such shop, factory, mill or industrial establishment was in operation and discharging refuse or waste matter, . . . on or prior to May 7, 1903, and such municipality or the proprietor of such shop, factory, mill or industrial establishment secured exemption from this section by filing a report with the state commissioner of health . . ., nor to any extension or modification of such shop, factory, mill or industrial establishment, or reconstruction thereof, provided the refuse or waste matter discharged therefrom is not materially changed or increased; but this exception shall not permit any increase in the discharge of such sewage, or in the discharge of refuse or waste matter from any shop, factory, mill, or industrial establishment, nor shall it permit the discharge of sewage from a sewer system which shall be extended, modified or reconstructed subsequent to said date."

Section 76a states:

"Whenever the state commissioner of health shall determine upon investigation that sewage from any city, village, town, building, steamboat or other vessel, or property or any garbage, offal or decomposable or putrescible matter of any kind is being discharged into any of the waters of the state, . . ., and when, . . . , such discharge is polluting such water in a manner injurious to, or so as to create a menace to health, or so as to create a public nuisance, he may order the municipality, corporation or person so discharging sewage, refuse or other matter, to show cause before him why such discharge should not be discontinued . . . The state commissioner of health shall take evidence in regard to said matter and he may issue an order to the municipality, corporation or person responsible for such discharge, directing that within a specified period of time thereafter such discharge be discontinued, and such proper method of treatment or disposal of such sewage, refuse or waste matter be installed as shall be approved by the state department of health . . . But this section shall not apply to refuse or waste matter from any shop, factory, mill or industrial establishment not containing sewage . . ."

(3) Connecticut. - The State Water Commission, under provisions contained in Chapter 142 of the General Statutes, has authority to compel treatment of wastes and can act against establishment of any new source of pollution. Section 2557 states:

"If, upon hearing, the commission shall find that any person, firm or corporation is polluting the waters of the state, it may make an order directing such person, firm or corporation to use or to operate some practicable and reasonably available system or means which will reduce, control or eliminate such pollution having regard for the rights and interests of all persons concerned, provided the cost of installation, maintenance and operation thereof shall not be unreasonable or inequitable. Such order shall specify the particular system or means to be used or operated; provided, if there shall be more than one such practicable and reasonably available system or means, such order shall give to such person, firm or corporation the right to choose which one of such systems or means shall be used or operated."

Section 2559 is as follows:

"No person, firm or corporation shall create, establish, cause or maintain any source of pollution not existing June 23, 1925, provided said (State Water) commission, after hearing and investigation, upon application of any person, firm or corporation, may issue such order relating to any pollution as it shall find will best serve the public interest."

Chapter 141, Section 2547, conferring pollution abatement authority on the State Department of Health, states:

"No person, corporation or municipality shall place in or permit to be placed in, or discharge or permit to flow into, any of the waters of the state, any sewage prejudicial to public health. The state department of health may investigate all points of sewage discharge and may examine all existing or proposed public sewerage systems and refuse disposal plants, and may compel their operation in a manner which shall protect the public health or may order their alteration, extension and replacement when necessary for the protection of public health, and the qualifications of the operators of sewage-treatment plants shall be subject to the approval of the state department of health. No public sewerage system or refuse disposal plant shall be built until the plan or design of the same shall have been filed with the state department of health and approved by said department, and no such system or plant shall be built, extended or replaced, the effluent or discharge from which may or shall directly or indirectly mingle or come in contact with the waters of the state until the plan for the same shall have been approved by the state water commission under the provisions of Chapter 142."

7. OIL POLLUTION LAWS.

a. Federal. - Public Document 238, Sixty-eighth Congress, first session, the "Oil Pollution Act of 1924," deals specifically with deposition of oil from vessels on coastal navigable waters, such as the

Housatonic River below Shelton, Connecticut. Federal courts have ruled that provisions of the River and Harbor Act of 1899, referred to in paragraph 6a above, apply also to the discharge of oil.

b. State. - The general pollution laws of New York and Connecticut may be interpreted to cover contamination caused by oil or its products. Section 59 of the Massachusetts General Laws, Chapter 91, is the only State law specifically designed to prevent oil pollution. This statute states:

> "Whoever pumps, discharges or deposits, or causes to be pumped, discharged or deposited, into or on the waters of any lake or river or into or on tidal waters and flats, any crude petroleum or any of its products or any other oils or any bilge water or water from any receptacle containing any of said substances, in such manner and to such extent as to be a pollution or contamination of said waters or flats or a nuisance or be injurious to the public health, shall be punished by a fine of not more than five hundred dollars; but this section shall not be construed to prohibit the use of oil for the extermination of mosquitoes or other insects."

8. LAWS ON POLLUTION OF WATERWAYS BY REFUSE. - The Federal law regulating this type of pollution is embodied in Section 13 of the River and Harbor Act quoted in paragraph 6a. Pollution by refuse is also prohibited by the public health laws of the State of New York, as outlined in 6b(2), preceding. The Connecticut law is embodied in Chapter 142, Section 2560, which states:

> "No person or municipal or private corporation shall deposit any garbage, domestic refuse or other material of like nature in the waters of any river, stream, pond, lake or tidal waters of this state or . . . on any land within a distance of fifty feet of the high-water mark of any such waters or in any place where storm or high water may carry such material to an adjacent waterway . . ."

9. POLLUTION ABATEMENT ACTIVITIES.

a. Federal. - Other than the enforcement of the existing Federal laws, no special pollution abatement measures for the Housatonic River Watershed have been undertaken by the Federal Government.

b. Interstate cooperation. - Because of the interstate nature of the Housatonic River Watershed, any comprehensive improvement program must depend in part upon cooperation among the three States concerned, with emphasis upon coordination of efforts between Massachusetts and Connecticut, where the problem is more acute. In 1935 the General Assembly of the State of Connecticut passed Special Act 527 authorizing appointment of a commission to deal with the Federal Government and other New England States in problems "relating to the development and improvement, including elimination of pollution" of waters common to any two or more of them. In 1936 the Massachusetts Legislature authorized its State Planning Board to enter into compacts with the Federal Government and with other States for similar improvements of its interstate waterways. To date the only formal interstate pollution abatement compact entered into is that concerning the abatement of pollution in the tidal portion, which is discussed in paragraph 9c below. In 1937 an organization known as the "Housatonic Valley Associates" was formed for the purpose of improving the condition of the river and for promoting recreational facilities thereon. This group, made up of interested officials and residents of the valley, adopted a resolution for a permanent organization to study such problems as pollution control, and restoration and protection of the river.

c. Tri-state Treaty Commission. - In 1931, a joint commission was created by the States of New York, New Jersey, and Connecticut to abate pollution of coastal and harbor waters. The sanitation district includes the Housatonic River from Long Island Sound to the northerly boundaries of the towns of Stratford and Milford. Final ratification of the Commission's compact in 1936 by New York and New Jersey made it the first formal and binding pollution abatement agreement between States. While the installation of sewage-disposal plants

Unlike the Thames and Blackstone Watersheds, where financial conditions are the sole deterrent to treatment of trade wastes, the principal difficulty here lies in the lack of suitable methods for purifying metallurgical waste waters. Recovery of usable by-products has not reached the perfection that would enable financial return commensurate with the cost of installing and operating waste treatment equipment. Although manufacturers are anxious to cooperate in all reasonable measures to reduce pollution, they are reluctant to make a large initial expenditure, followed by an increase in recurring operating costs. It has been the aim of all communities to treat wastes from the industries with the municipal sewage if possible. Since most of the municipal sewage-disposal systems in the Housatonic Basin use the activated sludge process, treatment of large quantities of wastes from the metal industries has not been practicable. In some instances it is advantageous to give preliminary treatment to certain trade wates. This is especially true for the hat factories, whose fibrous organic wastes cause a clogging mat to form on filtration beds.

13. REFUSE DISPOSAL. - In the Housatonic Watershed, particularly along the Naugatuck River, there are several rubbish dumping grounds located along stream banks below high-water levels. While these are not major sources of pollution, any steps to effect an improvement of waterways should consider them. Municipal garbage reduction or refuse incineration plants are the best means for sanitary disposal, and should be established where feasible. At present there are none in the watershed. In certain of the larger communities and in the vicinity of industrial plants there is promiscuous dumping of solid wastes directly into the streams. When financial conditions prohibit incineration of municipal refuse, wastes may be inexpensively disposed of in segregated areas not adjacent to streams serving downstream communities.

f. Connecticut. - The State Water Commission has the legal right to conduct hearings to establish the facts regarding any certain source of pollution and to issue orders requiring its correction. The law does not authorize issuance of any order requiring cessation of pollution, but permits only orders "to use or to operate some practicable and reasonably available system or means which will reduce, control or eliminate pollution." While it might appear that pollution abatement would be facilitated if the Commission had authority to order immediate cessation of pollution, a long-range view of the problem shows that this is not the case and that the present Connecticut law furnishes the wisest method of approach in that State. The Water Commission must first determine the nature of the specific problem, secondly devise a method of treating the particular waste, and finally require the offender to construct or install the equipment needed to treat the waste. For a municipality, this might be a sewage-treatment plant; for a factory, a chemical or mechanical device. The steps are time-consuming and expensive. The State is prepared to specify the particular method by which wastes may be treated, leaving the cost of installing the equipment the only obstacle. The Water Commission's program has been first to require municipalities to have a comprehensive engineering study made, the work planned then being divided into a series of units. Communities are then urged to take up the work required step-by-step. Within the Housatonic River Watershed progress has been made in the treatment of domestic wastes, even in the smaller communities. The Water Commission's pollution abatement program has its greatest difficulties in the cities along the lower reaches of the Naugatuck River. Here, communities, at or near their legal debt limits, have found it impossible at this time to undertake costly construction projects. There is also a general lack of coordination between neighboring communities as to pollution abatement policies, and a tendency for each to delay installation of treatment plants pending similar action by upstream riparian polluters.

Character and Treatment of Wastes

10. PURPOSE OF WASTE TREATMENT. - Treatment of sanitary and industrial wastes has the ninefold purpose of preventing the following: (1) pollution of waters intended for domestic use, (2) damage to private property, (3) damage to industry through pollution of waters needed for manufacturing processes, (4) infection of cattle by pollution of their water supply, (5) damage to commercial fisheries, especially contamination of shellfish, (6) annoyance due to offensive odors and fumes, (7) interference with recreational uses such as bathing, camping, and fishing, (8) contamination of and aesthetic damage to water supplies, and (9) interference with navigation by filling in channels with waste deposits.

11. DOMESTIC SEWAGE. - About 74 percent of the watershed population is served by organized sewerage systems, either municipally or privately owned. Among the latter are those operated by factory management in certain of the smaller mill communities. Table I, following, contains up-to-date estimates of the population sewered, with and without treatment, in the three States of the watershed.

TABLE I - APPENDIX E

ESTIMATED POPULATION* OF HOUSATONIC RIVER WATERSHED SERVED BY ORGANIZED SEWERAGE SYSTEMS AND TREATMENT PLANTS

Facilities	Massachusetts		New York		Connecticut		Entire watershed	
	Population	Percent	Population	Percent	Population	Percent	Population	Percent
Sewered with complete treatment	47,600	59.3	10,400	57.5	64,900	20.5	122,900	29.7
Sewered with partial treatment	2,500	3.1	0	0.0	11,800	3.7	14,300	3.5
Sewered with no treatment	15,200	19.0	1,000	5.5	153,700	48.7	169,900	41.0
Unsewered; rural disposal methods	14,900	18.6	6,700	37.0	85,400	27.1	107,000	25.8
State total	80,200	100.0	18,100	100.0	315,800	100.0	414,100	100.0
Watershed total	-	19.4	-	4.4	-	76.2	-	100.0

* Population is estimated for 1940 on basis of following percentages of increase over 1930 Federal Census figures: Massachusetts 5, New York 5, and Connecticut 8 percent.

Table I shows that 33 percent of the entire population, or 45 percent of the sewered population, is served by treatment plants. The largest communities having sewer systems but no treatment plants are Dalton, Great Barrington, and Lee, Massachusetts, and the several cities in the Naugatuck Valley such as Thomaston, Waterbury, Naugatuck, Ansonia, and Derby, Connecticut. While dilution is an accepted means of disposal, a river may be compared to a septic tank, both being unsatisfactory means of disposal when their rated capacities are exceeded. Studies show that the Housatonic River is ordinarily capable of bearing its sewage load, but that the Naugatuck River is polluted, in its lower reaches, beyond its capacity to dilute. The treatment plants now existing are nearly all modern in design and, with the exception of six small installations, complete purification is provided. Unlike other New England watershed pollution abatement programs, the trend is toward complete rather than only preliminary treatment. In the Housatonic Basin, the activated sludge process is predominant with no installations of the newer chemical precipitation methods. Plate No. 1, appendix E, shows the locations of the several sewered communities and treatment plants. These plants, their processes, and the degrees of purification are described in paragraphs 16 to 20 on stream conditions. Each plant is operated to give the maximum possible degree of purification from available equipment. In all cases, the operation of sewage-disposal plants is under supervision of the health department of the State concerned. Periodic inspections are made and samples of untreated sewage and effluent are analyzed. Whenever the effluent is unsatisfactory according to the State health department standards, remedial measures can be required. These measures might consist of modifications in operation procedure, enlargements of plant capacities, or more complete operator supervision. As in other public health programs, the economic situation remains the paramount factor in watershed improvement and funds available for installation of additional treatment equipment limit the quality of effluent. In the unsewered areas, ordinarily the only possible stream pollution from outhouses, cesspools, or properly operated septic tanks is through seepage, but health authorities agree that there is a definite health menace in the use of rural sanitary facilities. Estimates given in Table I indicate that a population of 107,000, or 25.8 percent of the watershed total, is served by these disposal methods.

12. INDUSTRIAL WASTES. - Like other watersheds in southern New England, there is extensive industrialization, particularly in the Naugatuck Valley. The trade waste situation is not serious except along the Naugatuck River, where, according to the Connecticut State Water Commission, this problem is worse than elsewhere in the State. Factory wastes become a serious menace in a watershed, like the Housatonic, in which clean streams are desired for recreational purposes.

a. Type of industry. - The Housatonic River in Massachusetts has for its principal industry the manufacture of high-grade paper, with plants at Dalton, Pittsfield, Lenox, Lee, and Great Barrington. Other products include electrical equipment, household gas, textiles, leather goods, rabbit fur, and dairy goods. Numerous dairies are located in the western part of the area. In Connecticut, Danbury is noted for its felt hat factories. The Naugatuck Valley has Torrington, a hardware and brass finishing center; Thomaston, noted for its clocks; Waterbury, the "Brass City"; and the highly developed cities of Naugatuck, Ansonia, Derby, and Shelton. Metallurgical industries are predominant in the southern part of the drainage area. Compared with the Thames and Blackstone Basins, there is relatively little textile and much more metal industry.

b. Character of industrial wastes. - In evaluating trade wastes, it is helpful to compare their strengths with those of domestic sewages. Typical values are given in Table II, following. City sewage analyses are from the 1938 report[6] of the Massachusetts Department of Public Health, and the industrial waste analyses from the Seventh Biennial Report[5] of the Connecticut State Water Commission. The significance of the various chemical constituents, listed in Table II, is discussed in paragraph 14<u>a</u> of this appendix.

TABLE II - APPENDIX E

TYPICAL ANALYSES OF SEWAGE AND TRADE WASTES

Type of waste	Suspended solids, p.p.m.	Oxygen consumed, p.p.m.	Biochemical oxygen demand, p.p.m.	Reaction			Metals present, p.p.m.
				pH	Acid, p.p.m.	Alkali, p.p.m.	
<u>Sewage</u>							
Pittsfield	139	48	231	5.8	0	184	Iron 1.6
Lenox	87	37	81	6.8	0	200	Iron 0.8
Stockbridge	66	32	182	5.6	0	153	Iron 0.4
<u>Industrial</u>							
Dairy	3,000	1,500	2,800	5.0	-	-	None
Brewery	5,000	15,000	5,000	6.8	trace	0	Traces of iron, tin, lead, copper
Laundry	700	800	1,000	9.0	0	5	None
Paper	300	1,000	700	7.2	0	0	None
Woolen	500	1,000	1,000	8.0	0	5	None
Cotton	600	800	700	7.0	0	2	None
Silk	1,000	1,200	1,000	7.3	0	0	None
Rayon	1,200	780	1,300	6.8	0	0	None
Steel pickle, strong	200	0	0	1.0	30,000	0	Iron 14,000, copper 10, zinc 10
Steel pickle, rinse	50	0	0	4.0	500	0	Iron 200, zinc 1, copper 1
Copper pickle, strong	200	190	0	1.0	100,000	0	Iron 600, lead 5, copper 40,000, zinc 45,000, chromium 5,000, tin 1
Copper pickle, rinse	60	40	0	5.0	500	0	Iron 16, zinc 160, copper 140, tin 5, chromium 30, lead 3

Based upon the biochemical oxygen demand, figures in Table II show that textile and dairy wastes are from four to seventeen times as strong as an average municipal sewage. The high acidity and metal content of steel and copper pickle wastes are obviously detrimental to bacteriological processes such as are utilized in the activated sludge method of sewage treatment. Manufacturers claim that these acid metallurgical wastes are helpful in reducing the content of harmful bacteria in streams, but State authorities feel that this is outweighed by the various detrimental effects. Copper pickle liquors, discharged in quantity in the Naugatuck Basin, have a high oxygen-consuming power, despite their inorganic composition. Paper mill wastes, discharged in the upper Housatonic River, have four times the oxygen demand of domestic sewage. Laundry wastes, emanating from all cities, are objectionable mainly because of the turbidity they impart to treatment plant effluents.

c. Treatment of industrial wastes. - In the last fifteen years much research on the treatment of industrial wastes has been undertaken by State agencies, particularly the Connecticut State Water Commission. Studies are made to determine the effect of trade wastes upon the design and operation of new sewage-disposal systems, so that decisions can be reached as to which wastes can be included in the sanitary sewage, and which require separate preliminary treatment. While none of the municipal sewage-disposal plants in the Housatonic River Watershed is equipped to accommodate large volumes of trade wastes, there are certain ones which at present can handle dilute wastes from the smaller factories.

(1) Massachusetts. - In Pittsfield the sewage-treatment plant handles trade wastes from household gas, textile, dairy, laundry, and cleaning establishments. Strong organic wastes from a large tannery also enter the treatment plant but not until preliminary settling has taken place in a specially provided tank at the factory. Paper mill wash waters, being sufficiently dilute, are discharged untreated directly into

the Housatonic River at Pittsfield. A rawhide tannery, located in New Marlborough, Massachusetts, has also provided settling tanks and a lagoon for primary treatment. At Lee a paper mill, discharging a million gallons of wastes daily, and a small laundry have lagoons and facilities for sedimentation prior to discharge into the river. The paper mill also uses save-alls, consisting of troughs and screens, for recovering pulp from waste waters. Other trade waste treatment equipment is operated by a laundry in Great Barrington and a dairy at Sheffield.

(2) Connecticut. - Present trade waste treatment processes in use include a large chemical precipitation and filtration plant for textile wastes at Watertown, a preliminary settling tank for metallic wastes at Southbury, fine screens to remove fiber from hat factory wastes at Danbury, and an underground filtration system for purification of wastes from the candy factory at Beacon Falls. In an effort to develop a method of treating waste liquors from the pickling of copper and brass, with recovery of by-products, the State Water Commission set up a pilot plant at the Chase Brass Company in Waterville and extensive experimental work was done under the direction of Professor B. F. Dodge of Yale University. Tests conducted from March 1934 to date have evolved methods of recovering copper, chromium, and zinc but not on a commercially economical basis. Until such time as successful conclusions can be drawn from the investigations, the Naugatuck River probably must continue to receive harmful metallurgical wastes at Torrington, Thomaston, Waterbury, and other cities. The Connecticut statutes require the State Water Commission to suggest the manner or means to be employed in remedying any pollution.

d. Economics of industrial waste treatment. - The number of installations of trade waste treatment equipment in the Housatonic Watershed is evidence of the fact that the economic status of the industries in the basin is better than in other southern New England watersheds.

Unlike the Thames and Blackstone Watersheds, where financial conditions are the sole deterrent to treatment of trade wastes, the principal difficulty here lies in the lack of suitable methods for purifying metallurgical waste waters. Recovery of usable by-products has not reached the perfection that would enable financial return commensurate with the cost of installing and operating waste treatment equipment. Although manufacturers are anxious to cooperate in all reasonable measures to reduce pollution, they are reluctant to make a large initial expenditure, followed by an increase in recurring operating costs. It has been the aim of all communities to treat wastes from the industries with the municipal sewage if possible. Since most of the municipal sewage-disposal systems in the Housatonic Basin use the activated sludge process, treatment of large quantities of wastes from the metal industries has not been practicable. In some instances it is advantageous to give preliminary treatment to certain trade wates. This is especially true for the hat factories, whose fibrous organic wastes cause a clogging mat to form on filtration beds.

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Quality of Water

14. WATER ANALYSES. - The quality of river waters in a drainage basin is best indicated by the analytical results derived from regularly maintained sampling programs. The Massachusetts Department of Public Health conducts examinations of the important streams in the State, samples usually being collected during the low-flow months of June through November and analyzed at the Department laboratories. In Connecticut, catch samples are taken monthly by the State Water Commission and tested at the health department laboratories. Dissolved oxygen is determined only in the low-flow months of July, August, and September. No recent comprehensive analyses were available for the portion of the basin in New York. However, analyses of the Tenmile River above the Connecticut line, given in paragraph 14 c, show the amount of pollution entering the main stream from that part of the drainage area. The results of the examinations are presented in accompanying paragraphs. Plate No. 1, Appendix E, shows the locations of sampling stations in the watershed.

a. Chemical constituents. - For proper understanding of the analyses given, brief statements relative to certain of the tests follow:

(1) Total solids represent the amount of organic and inorganic matter in suspension and in solution.

(2) Suspended solids represent the amount of organic and inorganic matter in suspension.

(3) Free ammonia in water indicates the presence of decomposing organic substances which may contain disease germs. A high ammonia content indicates recent pollution.

(4) Nitrites and nitrates are a measure of the progress of oxidation. High values indicate that purification is taking place or has occurred.

(5) Chlorides are a measure of the domestic or industrial wastes in river waters. They do not, however, measure the age of pollution.

(6) Alkalinity is a measure of the carbonate, bicarbonate, and hydroxide content of the water expressed in parts per million in terms of calcium carbonate.

(7) Hydrogen-ion concentration is a measure of the acidity or alkalinity of the water, generally expressed as the "pH", the logarithm of the reciprocal of the hydrogen-ion concentration. A pH of 7 indicates a neutral solution, greater values being alkaline and lesser values acid.

(8) Biochemical oxygen demand is a measure of the oxygen required to stabilize the decomposable organic matter by natural biological action. It is generally expressed as the oxygen, in parts per million, that is used up in five days at a temperature of 20 degrees Centigrade. Objectionable conditions arise when the demand exceeds the oxygen available in the stream.

(9) Dissolved oxygen is the ratio of the oxygen in solution to the amount which would be in solution if saturated at the given temperature. It is generally expressed as the percent saturation. Sanitary engineers are generally agreed that objectionable conditions are most apt to occur when the dissolved oxygen content is less than 50 percent and that values below 25 percent indicate exceedingly bad conditions.

(10) Oxygen consumed is a measure of the oxygen required to oxidize the decomposable organic matter in the water. It is not as reliable as the biochemical oxygen demand test because it depends upon artificial (chemical) means to bring about total oxidation. The presence of certain substances, such as nitrites, ferrous salts, and hydrogen sulfide, will cause increases in the values.

b. Housatonic River Watershed in Massachusetts. - The State Department of Public Health has for several years maintained sampling stations in the Housatonic River Basin. The Figures given in Table III are averages of analyses of four catch samples taken at each station between July 6 and October 2, 1939. During this period rainfall and run-off were less than normal, creating conditions worse than in ordinary dry seasons.

(Table on following page)

TABLE III - APPENDIX E

WATER ANALYSES - HOUSATONIC RIVER WATERSHED IN MASSACHUSETTS - 1939

Sampling station	Total solids, p.p.m.	Free ammonia, p.p.m.	Nitrates, p.p.m.	Chlorides, p.p.m.	Alkalinity, p.p.m.	Biochemical oxygen demand, p.p.m.	Dissolved oxygen, per-cent saturation.
Housatonic River above Hinsdale	82	.040	.12	4.5	44	3.0	90
Housatonic River above Dalton	94	.068	.20	4.8	54	2.1	90
Housatonic River above Pittsfield	139	.277	.15	3.7	96	4.2	52
Housatonic River above West Branch	162	.296	.15	5.2	102	4.7	40
Southwest Branch above West Branch	182	.193	.18	4.6	123	2.7	87
West Branch above Onota Brook	138	.257	.10	13.6	71	5.1	69
West Branch above Southwest Branch	188	.864	.11	36.8	86	6.8	52
Housatonic River below all branches	159	.475	.16	10.8	103	3.4	50
Housatonic River at New Lenox	187	.420	.64	14.1	107	2.8	40
Housatonic River at Lenox	178	.207	.48	13.1	108	3.5	66
Housatonic River below Lee	197	.104	.33	15.2	118	6.9	66
Housatonic River at Stockbridge	190	.067	.31	11.7	115	4.6	73
Housatonic River below Great Barrington	193	.073	.24	10.6	124	5.1	82
Housatonic River at Ashley Falls	177	.036	.25	9.3	121	4.3	96

The analyses indicate considerable fluctuation in the pollutional load as the stream flows through the State. The biochemical oxygen demand is low at Hinsdale but the addition of wastes at Dalton and Pittsfield causes an increase. The Southwest Branch is not badly polluted, but the oxygen demand on the West Branch shows the influx of wastes. Sufficient self-purification occurs on the headwater branches, however, since there is but little effect on the main stream. At Lenox the pollutional load again increases, attaining a maximum below Lee. From this point to the State line there is a decrease in the oxygen demand except for a slight rise occasioned by the addition of wastes at Great Barrington. Free ammonia, chloride, and nitrate results have the same trend and bear out these conclusions. The dissolved oxygen content in general is not low enough to promote offensive conditions, averaging 68 percent for the main stream and 69 percent for the tributaries, with a minimum of 40 percent on the main stream and 52 percent on the branches.

c. Housatonic River Watershed in Connecticut. - Water analyses, given below in Table IV, were obtained from the Connecticut State Water Commission. Although the figures for three of the stations are from 1937 and 1938 analyses, they are comparable with the more recent figures for the other stations because there have been no significant changes in watershed conditions in the meantime.

TABLE IV - APPENDIX E

WATER ANALYSES - HOUSATONIC RIVER WATERSHED IN CONNECTICUT

Station and date of sample	Suspended solids, p.p.m.	Free ammonia, p.p.m.	Nitrites and nitrates, p.p.m.	Hydrogen-ion concentration pH	Chlorides, p.p.m.	Alkalinity, p.p.m.	Biochemical oxygen demand, p.p.m.	Dissolved oxygen, percent saturation.
Housatonic River at Salisbury								
6-14-37	4.4	.080	.212	7.4	4.0	100	1.4	93.0
7-21-37	4.4	.010	.312	7.7	4.4	100	1.2	103.2
8-11-37	5.4	.040	.104	7.6	7.6	110	1.7	96.4
9-21-37	2.2	.100	.077	7.3	3.6	100	1.0	95.7
10-19-37	3.0	.200	.208	7.4	3.8	120	1.4	-
11-16-37	4.2	.010	.075	7.4	2.8	79	0.6	-
12-21-37	3.2	.040	.302	7.3	3.0	97	0.5	-
2-15-38	4.4	.000	.023	7.1	1.8	75	0.4	-
3-8-38	4.4	.040	.210	7.1	2.4	82	1.6	-
4-12-38	4.4	.020	.104	7.3	1.4	75	1.2	-
5-16-38	7.0	.000	.057	7.3	1.2	76	1.4	-

(Table continued on following page)

TABLE IV (Continued)

WATER ANALYSES - HOUSATONIC RIVER WATERSHED IN CONNECTICUT

Station and date of sample	Suspended solids, p.p.m.	Free ammonia, p.p.m.	Nitrites and nitrates, p.p.m.	Hydrogen-ion concentration, pH	Chlorides, p.p.m.	Alkalinity, p.p.m.	Biochemical oxygen demand, p.p.m.	Dissolved oxygen, per-cent saturation
Housatonic River at Newtown								
1-11-39	5.0	.060	.302	7.3	2.4	49	0.6	-
2-15-39	6.0	.100	.402	7.3	2.8	46	1.1	-
3- 8-39	12.	.000	.202	7.4	2.2	53	0.7	-
4-12-39	7.4	.000	.200	7.1	1.6	30	0.8	-
5-10-39	5.0	.000	.104	7.5	2.2	68	1.0	-
6-13-39	4.6	.080	.304	8.0	3.2	93	1.3	-
7-11-39	5.2	.000	.304	8.3	5.8	95	2.4	83.4
8-15-39	8.0	.000	.064	7.7	9.0	96	1.2	118.4
9-19-39	3.6	.000	.207	8.3	7.2	110	1.4	104.4
10-17-39	4.2	.000	.317	7.9	7.4	100	0.4	-
11-14-39	4.6	.000	.202	7.7	3.0	63	1.1	-
1- 3-40	1.8	.000	.302	7.1	2.8	28	0.7	-
1-17-40	5.6	.010	.102	6.5	2.0	10	1.8	-
Tenmile River above Connecticut State line								
6-14-37	7.0	.040	.204	7.6	3.8	110	1.3	106.0
7-21-37	4.0	.010	.041	8.4	7.8	150	0.8	138.7
8-11-37	5.2	.020	.104	7.9	5.8	140	1.3	100.4
9-21-37	1.0	.040	.104	7.7	3.4	140	0.9	107.7
10-19-37	3.0	.080	.205	7.7	4.4	160	1.4	-
11-16-37	4.2	.020	.050	7.7	3.4	100	0.8	-
12-15-37	14.	.060	.704	7.7	4.2	130	0.9	-
1-24-38	5.0	.020	.310	7.7	2.8	120	1.2	-
2-15-38	4.8	.000	.403	7.3	2.0	97	0.4	-
3- 8-38	6.0	.020	.402	7.3	2.8	96	1.0	-
4-12-38	5.8	.000	.204	7.3	1.6	91	0.6	-
5-16-38	4.8	.020	.104	7.7	1.0	91	1.6	-
Shepaug River near Roxbury								
1- 4-39	4.4	.040	.300	7.1	1.2	18	0.9	-
2-15-39	290.	.220	.200	6.7	2.2	18	4.7	-
3- 8-39	5.8	.010	.100	7.0	1.4	18	0.5	-
4-12-39	6.6	.010	.100	7.1	1.0	14	0.5	-
5-10-39	2.8	.000	.050	7.1	1.2	22	1.5	94.1
6-13-39	1.8	.040	.052	7.3	3.0	28	0.6	108.7
7-11-39	4.4	.000	.070	7.1	2.0	28	1.3	107.9
8-15-39	14.	.000	.030	6.7	3.2	22	0.8	-
9-19-39	6.4	.000	.050	7.3	1.6	33	2.0	-
10-17-39	2.2	.000	.030	7.1	1.8	31	0.6	-
11-14-39	2.8	.000	.100	7.3	1.4	24	0.4	-
12-27-39	1.4	.020	.201	7.1	2.2	24	0.7	-
1-17-40	5.8	.000	.102	6.7	1.4	14	1.6	-

(Table continued on following page)

TABLE IV (Continued)

WATER ANALYSES - HOUSATONIC RIVER WATERSHED IN CONNECTICUT

Station and date of sample	Suspended solids, p.p.m.	Free ammonia, p.p.m.	Nitrites and nitrates, p.p.m.	Hydrogen-ion concentration, pH	Chlorides, p.p.m.	Alkalinity, p.p.m.	Biochemical oxygen demand, p.p.m.	Dissolved oxygen, per cent saturation.
Pomperaug River at Southbury								
2-15-39	5.2	.000	.401	6.9	2.2	17	0.6	-
3- 8-39	5.0	.000	.200	7.0	2.0	16	0.4	-
4-12-39	8.2	.000	.200	6.9	1.6	12	0.2	-
5-10-39	3.8	.000	.201	7.1	1.8	18	0.6	-
6-13-39	3.4	.000	.100	7.5	1.2	26	0.5	-
7-11-39	2.4	.000	.301	7.1	4.4	29	1.9	117.1
8-15-39	4.2	.000	.504	7.3	3.8	31	1.8	106.3
9-19-39	1.6	.000	.401	7.3	3.4	31	2.2	100.0
10-17-39	6.4	.000	.301	7.1	3.0	31	0.8	-
11-14-39	2.8	.060	.200	7.3	2.4	20	0.9	-
12-27-39	1.6	.010	.301	6.9	2.6	20	0.7	-
1-17-40	4.8	.000	.201	6.7	2.0	13	1.1	-
Leadmine Brook near Thomaston								
6- 8-37	2.0	.000	.100	6.8	4.8	14.	0.8	97.7
7-14-37	2.0	.000	.030	6.9	1.4	8.0	0.8	96.8
8-16-37	1.2	.000	.030	6.9	2.0	12.	0.7	106.8
9-22-37	2.6	.000	.052	7.0	2.4	12.	0.6	105.2
10-13-37	2.8	.000	.020	6.9	2.0	12.	1.1	-
11-17-37	0.8	.000	.021	6.6	2.4	8.0	0.6	-
12- 8-37	2.6	.000	.070	6.5	2.2	6.0	0.3	-
3- 9-38	1.6	.000	.031	6.5	2.0	7.0	1.5	-
4-11-38	2.8	.010	.057	6.5	1.2	7.0	0.9	-
5-25-38	4.0	.080	.050	6.7	0.8	10.	1.1	-
Naugatuck River near Thomaston								
2-14-39	6.2	.280	.410	6.9	3.6	15	4.6	-
3-15-39	4.6	.180	.307	6.9	3.0	13	2.0	-
4-19-39	16.	.030	.202	6.9	2.6	13	1.8	-
5- 8-39	2.2	.220	.214	6.7	2.6	17	1.6	-
6-12-39	7.4	.450	.304	6.9	5.4	22	4.0	-
7-20-39	26.	.950	.390	6.7	8.2	10	7.3	129.4
8-16-39	14.	.600	.480	7.1	6.8	26	5.2	113.3
9-20-39	12.	.950	.640	6.7	6.6	21	3.7	112.5
10-11-39	6.8	.720	.330	6.9	6.4	20	4.6	-
11-13-39	12.	1.200	.320	6.7	4.6	26	7.5	-
12-13-39	15.	.900	.212	6.5	6.0	21	13.	-
1-11-40	5.6	.800	.319	6.5	5.0	13	2.5	-

(Table continued on following page)

TABLE IV (Continued)

WATER ANALYSES - HOUSATONIC RIVER WATERSHED IN CONNECTICUT

Station and date of sample	Suspended solids, p.p.m.	Free ammonia, p.p.m.	Nitrites and nitrates, p.p.m.	Hydrogen-ion concentration, pH	Chlorides, p.p.m.	Alkalinity, p.p.m.	Biochemical oxygen demand, p.p.m.	Dissolved oxygen, percent saturation.
Naugatuck River at Beacon Falls								
2-14-39	8.4	.900	.510	6.7	4.4	12	6.8	-
3-15-39	7.8	.200	.408	6.9	5.8	15	5.0	-
4-19-39	48.	.140	.320	6.1	3.4	5	4.7	-
5- 8-39	2.6	.420	.420	6.5	4.4	15	4.4	-
6-12-39	8.2	1.100	.330	6.7	8.8	30	6.6	-
7-20-39	14.	2.000	.380	6.7	16.	30	23.	56.7
8-16-39	12.	1.100	.690	6.5	13.	20	6.4	71.3
9-20-39	18.	1.300	.030	6.7	15.	33	14.	-
10-11-39	13.	1.160	.440	6.3	3.4	12	9.3	-
11-13-39	21.	.340	.256	6.5	7.6	25	17.	-
12-13-39	18.	.420	.225	6.5	6.8	12	9.8	-
1-17-40	18.	1.100	.078	3.9	1.6	7	12.	-

A comparison of the analyses for Ashley Falls, Massachusetts, given in paragraph 14 b, and those for Salisbury, Connecticut, shows appreciable improvement at the latter station. The dissolved oxygen content, lowest during the summer months, is sufficient to prevent offensive conditions. The biochemical oxygen demand is very low, indicating the absence of any large amounts of organic matter. Suspended solids, free ammonia, nitrites and nitrates, and chloride results bear out these conclusions. Alkalinity is high and the pH averages 7.4, reflecting the high alkalinity of the natural waters of northwestern Connecticut and neighboring New York. At Newtown the river is still in excellent condition, showing that the Tenmile, Shepaug, and Pomperaug Rivers have no detrimental effect upon the main stream. Examination of analyses of these tributaries shows their waters to be in good sanitary condition. Low oxygen demand and a dissolved oxygen content generally exceeding 100 percent indicate the absence of large amounts of objectionable matter. There is some fluctuation in suspended solids but it is not caused by organic material. Leadmine Brook, which enters the Naugatuck River above Thomaston, is in good condition, oxygen demand being low and oxygen content high. At Thomaston the Naugatuck River shows evidence of pollution. The oxygen demand, though not excessive, indicates the introduction of organic matter. This conclusion is further borne out by the high content of suspended solids, nitrites and nitrates, free ammonia, and the increased chlorides. As indicated by the lower alkalinity analyses and the pH values averaging less than 7.0, the waters in this portion of the Housatonic River Basin are not so alkaline as those of the main river. The oxygen supply at Thomaston is adequate, averaging 118.4 percent. The Naugatuck at Beacon Falls is more seriously polluted than at Thomaston. The oxygen demand is higher, averaging 9.9 parts per million with a maximum of 23. The oxygen available is less than at any other station. The suspended solids, free ammonia, nitrite and nitrate, and chloride contents fluctuate considerably, showing the continual addition of wastes.

15. WATER SUPPLIES. - The results in Tables III and IV of this appendix indicate that, with the exception of the Naugatuck River, the streams in the watershed are in good sanitary condition. Both the surface and ground waters are low in iron and higher in hardness than other New England natural waters. The hardness is due to the extensive limestone deposits, principally in the western portion of the drainage area. Within the Housatonic Basin there are several water supplies of suitable quality for domestic and industrial uses. Nearly all the municipalities having public systems are able to satisfy their requirements from these sources. Recent investigations[2] show that in Massachusetts Lanesborough, Pittsfield, Hinsdale, Lenox, Lee, Stockbridge, Egremont, and Great Barrington are served by surface supplies, while Sheffield and West Stockbridge are served from ground-water sources. Four of these supplies, including Pittsfield, are chlorinated, the rest being used without treatment. In

Connecticut[7] public systems serve a population of about 234,000. Of this number, 77.5 percent are served by surface supplies with chlorination only, 18.8 percent by surface waters with chlorination and other treatment, 2.1 percent by surface supplies with no treatment, and 1.6 percent from ground-water sources with no treatment. In addition, there are several large institutional and semi-public supplies in the watershed, all of which are under State supervision.

Sanitary Conditions

16. SANITARY CONDITIONS IN THE WATERSHED. - The following paragraphs give a summary of sanitary conditions, pollution problems, and sewerage facilities in the Housatonic River Watershed. The information was obtained chiefly from the reports listed in paragraph 3 of this appendix, and was brought up to date by conferences with State officials. In addition to the municipal treatment works in the basin there are several institutional plants giving varying degrees of treatment. These are discussed in paragraph 20.

17. HOUSATONIC RIVER WATERSHED IN MASSACHUSETTS. - The Housatonic River Valley in Massachusetts is sparsely settled. The total population in the basin, according to 1935 State census figures, is about 74,100, of which nearly two-thirds is in the City of Pittsfield. Reference to the chemical analyses given in paragraph 14 b of this appendix shows the degree of pollution on the main stream and its tributaries, the Southwest Branch and the West Branch. Dalton, Hinsdale, Great Barrington, Lee, Pittsfield, Lenox, and Stockbridge are the only communities having public sewerage systems, the latter three having treatment plants for part of their domestic wastes. In the town of Lenox the villages of Lenoxdale, Lenox Furnace, and Lenox have sewer systems, with the sewage from the community of Lenox being treated by sedimentation and filtration. The effluent is collected in an underdrain system and allowed to seep into

the ground. At Pittsfield a modern plant, consisting of a settling tank, dosing tank, trickling filter, and two mechanically-cleaned secondary settling tanks, was placed in operation in 1937. The works serve about 80 percent of the population. In the village of Stockbridge the sewer system and treatment plant serve 80 percent of the inhabitants. In addition to the domestic sewage from the many public and private outlets, trade wastes are discharged into the Housatonic River at several points. Table V, following, summarizes these sources of industrial pollution.

TABLE V - APPENDIX E

INDUSTRIAL WASTES
HOUSATONIC RIVER BASIN IN MASSACHUSETTS[2]

City or town	Type of industry	Quantity of wastes, gallons per day
Dalton	Paper, woolen cloth	1,594,700
Pittsfield	Paper, laundry, woolen cloth, tannery, metal, gas	742,900
Lenox	Paper	650,000
Lee	Paper, laundry	4,172,800
Great Barrington	Cotton goods, paper, laundry	1,033,200
Sheffield	Dairy, fur	14,000
New Marlborough	Tannery	11,000*

* Partial treatment.

Referring to the investigation of sources of pollution in the Housatonic River Basin, made in 1936 by the Works Progress Administration, Massachusetts Senate No. 50[2] states:

> "The stream in many parts of its course is unsightly due to the presence of sewage and offensive matters dumped on the banks and bed of the stream in the thickly settled communities. Some attempts have been made to clean the channels of the stream in Pittsfield, but this cleaning has not resulted in any material improvement in the character of the water . . .
>
> "The towns of Lee and Great Barrington at the time of the investigation were using the main portion of the stream as an intercepting sewer; and the examination has shown that there are 135 sewer pipe outlets constructed by the towns or individuals in the thickly settled parts of Lee and 86 in the thickly settled parts of Great Barrington. The two municipalities and individuals owning property near the stream apparently have not hesitated to construct sewer pipes to the river at any convenient point . . .

"The towns of Lee and Great Barrington should proceed with the construction of intercepting sewers and sewage disposal works as early as practicable, and a similar program should be followed in Hinsdale and Dalton. The program also should provide for the proper treatment of the foul industrial wastes now discharged into the stream either at local treatment works or by industries."

18. HOUSATONIC RIVER WATERSHED IN NEW YORK. - The sparsely settled portion of the Housatonic River Watershed in New York is drained by the Green and Tenmile Rivers. The latter stream has the larger drainage area, including the communities of Amenia, Wassaic, Dover Plains, South Dover, Pawling, and Wingdale. Domestic wastes, in general, are disposed of by rural means and no significant amounts of either industrial or domestic wastes reach the streams. Although no detailed pollution surveys have ever been made in this region, no complaints or conditions of nuisance have been reported. The Swamp River, a tributary of the Tenmile, is used as an auxiliary source of water supply for the Harlem Valley State Hospital and the sanitation of the watershed is controlled by the rules and regulations of the State Department of Health.

19. HOUSATONIC RIVER WATERSHED IN CONNECTICUT. - Chemical analyses given in paragraph 14 d show that the Housatonic River is in good sanitary condition above the mouth of the Naugatuck River, but badly polluted in other zones. Estimates show that 73 percent of the Connecticut population in the watershed is sewered and 24 percent is served by treatment plants. Trade wastes are discharged into the streams without treatment from several cities and towns listed in Table VI, following.

(Table on next page)

TABLE VI - APPENDIX E

INDUSTRIAL WASTES

HOUSATONIC RIVER WATERSHED IN CONNECTICUT[4]

City or town	Type of industry	Quantity, gallons per day	Stream into which discharged
New Milford	Bleaching, dyeing	200,000	Housatonic River
Danbury	Hat, fur, dyeing	2,500,000*	Still River
Bethel	Hat, tannery	15,000	Still River, Beaver Brook
Torrington	Brass, woolen, laundry	350,000	Naugatuck River
Thomaston	Clocks, brass	10,000	Northfield Brook
Watertown	Rayon, silk finishing	50,000*	Steel Brook
Waterbury	Brass, clock, metal, plating	8,000,000	Naugatuck and Mad Rivers, Steel, Hancock, & Great Brooks
Naugatuck	Rubber, chemical	2,000,000	Naugatuck River
Seymour	Metal	100,000	Naugatuck River
Ansonia	Brass, bleaching, dyeing	500,000	Naugatuck River
Derby	Metal, rubber, textile	10,000	Housatonic River
Shelton	Metal, rubber, textile	250,000	Housatonic River
Stratford	Brake lining	50,000*	Housatonic River

* Partial treatment.

Based upon pollution problems, the Housatonic River Watershed may be divided into three zones, namely, the portion above the mouth of the Naugatuck River, the drainage area of the Naugatuck River, and the part below the mouth of this tributary. In order to present best the cumulative picture, these portions will be discussed separately.

a. Housatonic River Watershed above the Naugatuck River. - According to the 1930 Federal Census the population in this part of the basin is about 81,000, of which 36 percent is in the city of Danbury. The valley, in general, is sparsely settled and presents few serious pollution problems. The population centers are widely distributed, affording ample opportunity for self-purification between pollution sources. Several of the communities have sewage-disposal as well as collection facilities. Following are pertinent data regarding the various treatment plants in this portion of the watershed:

Salisbury. - The Lakeville section, which contains about 20 percent of the town's population, is served by a sewerage system and treatment works. Equipment includes septic tanks, an Imhoff tank, and sand filters delivering effluent of good quality into the Housatonic River.

Norfolk. - About 80 percent of the population is served by the public sanitary sewer system and sewage disposal plant. Septic tanks and sand filters are employed to produce good effluent which is discharged into the Blackberry River.

North Canaan. - About half of the 2500 residents of North Canaan are served by the sewer system and treatment plant. As at Norfolk, septic tanks and sand filters are used, with discharge into the Housatonic River.

Sharon. - A private sewerage system and treatment plant, operated by the Sharon Drainage Company, serves 40 percent of the town's population. A septic tank and obsolete gravel filters produce a fair effluent.

Danbury. - Located along the headwaters of the Still River, Danbury, a city of 31,000 population, is the largest source of pollution in this section of the watershed. A municipal sewerage system and modern sewage-disposal works serve the entire city, except small areas in topographically unfavorable districts. The chief industry is the manufacture of felt hats, for which large quantities of rabbit fur are used. The fiber, skins, and organic wastes therefrom exert a tremendous oxygen demand on streams and, because of their clogging action on filters, require thorough screening before treatment. Although the majority of the hat factories are connected to the municipal treatment works, there is still a sizeable volume of untreated trade wastes reaching the river, causing obnoxious conditions downstream. If these remaining industrial plants are to be connected to the disposal works, some preliminary treatment will be required at the factories in order to remove the fiber and organic matter. The present disposal works, placed in operation in 1939, consist of mechanically-cleaned bar screens, fine screens, sedimentation tanks, trickling filters, separate sludge digestion tanks, and open sludge drying beds. Gas from the digestion tanks is used for heating purposes. The existing interceptors are overloaded and during periods of heavy rainfall large volumes of sewage and trade wastes are bypassed directly into the river. To remedy this condition the city is now constructing a new interceptor at a cost of $100,000. Promiscuous dumping of rubbish, garbage, and other miscellaneous refuse in the Still River has, besides creating an unsanitary nuisance in the city of Danbury, resulted in poor flow conditions. Gradual encroachment on the river banks and filling in of the channel have caused constrictions and obstructions which, during high water, accentuate flood damages. Conditions are most critical in the reach of the river from North Street to the White Street Bridge in the center of the city.

Litchfield. - The major portion of this town is served by a sewerage system and treatment plant, employing sand filters and chlorination with good results.

Recent inspections of the above treatment plants by the Connecticut State Department of Health showed them to be operating satisfactorily. Other towns which have sewerage systems but no treatment facilities include Kent, New Milford, and Shelton. The remaining communities in the basin use rural disposal methods with but slight contamination of waterways resulting.

b. Naugatuck River Watershed. - From the standpoint of population and industry, as well as pollution, the drainage basin of the Naugatuck River is the most important section of the Housatonic River Watershed. The population, according to 1930 Federal Census figures, is about 199,000. Above Torrington the river is in excellent sanitary condition, suitable even for trout, while the reach from Torrington to Thomaston is considered fair for fishing purposes. Below Thomaston, the area is densely populated and heavily industrialized, and the closely spaced pollution sources afford little opportunity for self-purification. Torrington and Watertown are the only communities having treatment works. The former put its disposal plant into operation during the past year, causing a marked improvement in the condition of the river. Treatment is provided for all of the sanitary and part of the trade wastes. At Watertown the recently enlarged sewage-disposal plant has Imhoff tanks, trickling filters, settling tanks, and separate sludge digestion tanks. The finishing and dyeing establishment in Watertown has one of the few installations for trade waste treatment in the watershed. Soap, dye, and wash wastes are treated by chemical precipitation. There is no recovery of by-products, so that the process is costly and justifiable only upon the basis of avoiding law suits by lower riparian owners. The effluent of both Watertown plants is discharged into Steel Brook, a tributary of the Naugatuck River. Waterbury, with a population exceeding 100,000, is the largest community in western New England without sewage-disposal facilities. Its old disposal plant was abandoned several years ago because of lack of funds, expensive royalties, and excessive operating costs. The present sewerage system, serving over 80 percent of the population, discharges its wastes into the Naugatuck River through a large outfall located on the right bank below the mouth of Mad River. The industrial wastes of the city are discharged into the Naugatuck and Mad

Rivers through several outlets. It would be necessary, in any general improvement program, to construct an interceptor to convey the Mad River trade wastes to a treatment plant. Naugatuck, Derby, and Ansonia have public sewerage systems, serving about 95 percent of their respective populations, but none of these cities has treatment facilities. The brass company in Ansonia provides partial treatment for its wastes. Copper pickle liquor is discharged into tanks in which evaporation occurs, allowing crystallization and recovery of copper sulfate. No special care is used in the process and no added operating costs result. Beacon Falls and Seymour have privately-owned sewer systems serving the major portion of the inhabitants. The State Water Commission has recommended that Ansonia, Derby, and Shelton, located within a two-mile radius at the junction of the Naugatuck and Housatonic Rivers, construct joint treatment works. Plans to this effect were drawn up and approved by the State but the project was dropped, necessitating individual action by the three adjoining cities. According to the State Water Commission, Waterbury is the key to the entire Naugatuck River pollution situation. Communities downstream have considered pollution abatement but have shown little desire to take any corrective measures while that large city continues to be the chief offender.

c. Housatonic River Watershed below the Naugatuck River. - The estimated population in this part of the watershed, based upon 1930 Federal Census figures, is 12,400. Stratford and Milford, the two largest communities in this section of the valley, do not contribute any significant amount of pollution. About 40 percent of the inhabitants in Stratford are served by the sewerage system and disposal works. Treatment is by Imhoff tanks and chlorination which give a fairly good effluent. The plant is now operating at peak capacity and the State Department of Health has recommended that additions be provided. The industrial wastes receive partial treatment before being discharged into a tributary brook. In April 1940, Devon, a section of Milford bordering the lower Housatonic River, announced that it plans to construct a sewerage system and a treatment plant, the latter estimated to cost about $55,000. The more densely populated portion of Milford is outside the watershed limits and contributes no wastes to the Housatonic River. This section of the watershed is polluted mainly by the inflow of waste-bearing waters of the Naugatuck River, discussed in the preceding paragraph.

20. INSTITUTIONAL TREATMENT PLANTS. - There are several institutional treatment plants, both public and private, in the Housatonic River Basin. These disposal works, in general, are operated by the health department of the State concerned. Equipment is more modern and efficiency higher, as a rule, than at municipal plants. The State of Connecticut has developed a policy of building sewage-treatment plants at public institutions as examples for communities and industrial corporations to follow. Such an institutional treatment plant is being provided at the new State hospital development in Southbury, Connecticut. These plants are designed to give at least the minimum treatment required for the stream into which they discharge. Table VII, following, gives pertinent data covering operation of the institutional plants in the basin.

TABLE VII - APPENDIX E

INSTITUTIONAL TREATMENT PLANTS - HOUSATONIC RIVER WATERSHED

Institution	Population	Treatment	Stream
Wassaic State School Wassaic, N. Y.	5,000	Imhoff tanks, trickling filters, chlorination	Wassaic Creek
Harlem Valley State Hospital Wingdale, N. Y.	5,400	Activated sludge, chlorination	Swamp River
Kent School Kent, Conn.	300	Septic tank	Housatonic River
Gunnery School Washington, Conn.	500	Sand filters	Shepaug River
Fairfield State Hospital Newtown, Conn.	900	Imhoff tanks, sand filters	Housatonic River
Laurel Heights State Sanatorium Shelton, Conn.	350	Imhoff tank, chlorination	Housatonic River

Stream Flow

21. MINIMUM FLOWS. - Discharge records for gaging stations operated by the United States Geological Survey show that low minimum flows have been experienced throughout the watershed, particularly during summer and fall months of the drier years. While there have been times of no flow on the Shepaug River at Woodville because of diversions for the water supply of the City of Waterbury, no objectionable conditions have resulted, because of lack of pollution sources along the stream. Likewise, Stevenson Dam on the Housatonic River at times has impounded all flow, but no nuisances have resulted downstream. From the sanitation standpoint, conditions are worst over weekends when flow is being conserved for subsequent use by industry. Table VIII, following, gives the lowest average daily flows, as determined from Water-Supply Paper 821 and preliminary figures for the year ending September 30, 1938.

TABLE VIII - APPENDIX E

MINIMUM FLOWS - HOUSATONIC RIVER WATERSHED

Gaging station	Period of record	Drainage area, square miles	Minimum average daily discharge	
			Cubic feet per second	Cubic feet per second per square mile
Housatonic River at Coltsville, Mass.	March 1936-Sept. 1938	57.1	4.4	0.077
Housatonic River near Great Barrington, Mass.	May 1913-Sept. 1938	280.	1.0	.004
Housatonic River at Falls Village, Conn.	July 1912-Sept. 1938	632.	24.0	.038
Housatonic River at Stevenson, Conn.	Aug. 1928-Sept. 1938	1545.	0.0	0
Tenmile River near Gaylordsville, Conn.	Dec. 1929-Sept. 1938	204.	13.0	.064
Still River near Lanesville, Conn.	Oct. 1931-Sept. 1938	68.5	11.0	.161

(Table continued on following page)

TABLE VIII (Continued)

Gaging station	Period of record	Drainage area, square miles	Minimum average daily discharge	
			Cubic feet per second	Cubic feet per second per square mile
Shepaug River at Woodville, Conn.	Oct. 1935-Sept. 1938	38.0	0.0	0
Shepaug River near Roxbury, Conn.	Oct. 1930-Sept. 1938	133.	6.8	.051
Pomeraug River at Southbury, Conn.	June 1932-Sept. 1938	75.3	5.8	.077
Leadmine Brook near Thomaston, Conn.	Sept. 1930-Sept. 1938	24.0	0.5	.021
Naugatuck River near Thomaston, Conn.	Oct. 1930-Sept. 1938	71.9	13.0	.181
Naugatuck River near Naugatuck, Conn.	June 1918-Sept. 1934, Sept. 1928-Sept. 1938	246.	40.0	.163

Sanitary engineers agree that a flow of from 4 to 6 cubic feet per second per thousand of sewage-contributing population is necessary to avert objectionable nuisances in streams used for sewage disposal. Computations of the sewage-bearing capacity of the Housatonic and similar rivers is complicated by the counteracting effects of self-purification through aeration and sedimentation, and the increased oxygen demand caused by trade wastes. Flow along the Housatonic River is generally high enough to bear the pollution load. Temporary population increases occur during the summer months when stream discharges are at their lowest and temperatures at their highest, resulting in nuisance conditions. The low flows on the Naugatuck River, where the population is most dense, cause extremely objectionable nuisances during the summer. Based upon the need for five cubic feet per second per thousand population, it may be shown that a flow not less than 750 cubic feet per second is necessary to avert unsanitary nuisances. This estimate is based upon only the sewered populations of Thomaston, Waterbury, Naugatuck, Beacon Falls, Ansonia, and Derby and does not include any population equivalents for industrial wastes. The mean discharge of the Naugatuck River near Naugatuck, Connecticut, is about 430 cubic feet per second, indicating the impossibility of completely eradicating the domestic pollution problems through flow conservation methods. Under ideal flow conservation conditions, it would be possible to provide only five times 430/750, or less than 3 cubic feet per second per thousand of sewage-contributing population. It is, however, obvious that any increase in flow will be of benefit, particularly until such time as the much needed sewage-treatment plants can be financed.

22. FLOW DIVERSION. - Other than minor water-supply diversions for towns located along the watershed boundaries, there are no important external developments decreasing or augmenting normal flows of Housatonic Watershed streams. The surface water supplies of all the larger cities are within the watershed. The City of Waterbury diverts flow from the Shepaug River to the Naugatuck Basin. While of minor importance, the flow is of greater benefit in the Naugatuck than it would be in the other valleys, which are unpolluted. The modifications in discharge caused by the numerous mill storage ponds located on tributaries tend to even stream flow. Likewise, the Rocky River development, by slightly increasing low-water flows, is of some benefit to Housatonic River sanitation.

Pollution Abatement Plans

23. STATE AND LOCAL PROPOSALS. - Both Massachusetts and Connecticut realize the recreational importance of the Housatonic River. Pollution control measures have been directed with this in mind. The agencies responsible for pollution abatement have specified treatment of all domestic wastes, and gradual progress is being made toward fulfillment

of this desire. To date conditions have been such that the treatment plants built serve only individual communities. The State of Connecticut recommended construction of a joint treatment plant to serve the cities of Ansonia, Derby, and Shelton. Lack of agreement among these communities has necessitated that they prepare three separate plans for individually treating their own wastes. Numerous other municipalities have, upon recommendation of State agencies, engaged consultants to draw up plans for sewage-disposal works. In 1914 the manufacturers of the Naugatuck Valley appointed a committee "to investigate the feasibility of the scheme of developing, impounding or compensating reservoirs on Lead Mine Brook, Harwinton, Connecticut".[9] It recommended the construction of a dam about one mile above the mouth of Leadmine Brook. The reservoir would have a drainage area of 22 square miles and a storage capacity of about 10,500 acre-feet. The committee's report states:

> ". . . the matter of conserving water in the Upper Naugatuck Drainage Basin is by far the most practicable method of materially increasing the stream flow of the Naugatuck River, and that the resultant improvement healthwise, industrially and otherwise to the cities and towns along its banks particularly below Waterbury would be so great that the matter is worthy of the most serious consideration.
>
> "Manufacturers, as individuals and corporations, have long pondered this idea, and municipalities have craved the adoption of this or any other plan that would give them relief, if no more than temporary, from unsolved sewage disposal problems and from stenches as unhealthy as they are repulsive. At present the lower Naugatuck River is an open sewer. To such an extent is it used for sewage disposal purposes that for upwards of 90,000 people living along its banks, south of Waterbury, it is an annual midsummer nuisance and menace. If it were not for the copious discharge of mill acids, some of which help to counteract the noxious sewage, conditions would no doubt be even worse than they are, if such could be possible."

It is evident from this report that the pollution problem in the Naugatuck Basin is an old one. Twenty-six years ago, when the population in the watershed was less than half of what it is today, conditions were such that public interest was aroused. Although no action was taken on the committee's recommendations for a storage reservoir, facilities for the treatment of domestic and industrial wastes have since been provided at several points in the basin.

24. EFFECT OF FLOOD CONTROL WORKS UPON WATERWAY POLLUTION.

a. Reservoirs. - The operation of storage reservoirs for the sole purpose of reducing flood discharges provides valuable sanitation benefits. Although no significant improvement in low-water flow may be expected, since the reservoirs will be regulated solely to keep flood losses at a minimum and will therefore be emptied as soon after heavy rains as downstream conditions permit, definite sanitation benefits result. Inasmuch as the proposed plan in this report includes only one reservoir, the benefit due to reservoirs will be limited. The proposed reservoir on the Naugatuck River at Thomaston, Connecticut, will be upstream from the heavily polluted section of the river. Although there are no sewage-treatment plants in operation on the Naugatuck River below Thomaston, the several plants proposed for Waterbury, Naugatuck, Ansonia, and Derby would be located on the flood plain and affected by high water. Some of the sanitation benefits traceable to Thomaston Reservoir are enumerated below.

(1) Protection of sewage-treatment plants. - Sewage-treatment plants are commonly located at the lowest suitable elevation to permit collection of sewage by gravity and reduce pumping costs. Cities and larger-sewered towns in the basin, shown on Plate No. 1, appendix E, are without exception situated on rivers, into which the

disposal of wastes, either raw or treated, is the cheapest and most convenient means of removal. As in other watersheds, treatment plants are located on flood plains downstream from the population centers served. In the floods of March 1936 and September 1938, operation of certain of these plants was interrupted by high water. Each flooding necessitates the discharge of raw sewage, and major delays result before the normal operating cycle of a plant can be restored. As in the starting of a new treatment plant, several weeks may elapse before bacteriological processes are restored to equilibrium. Flooding of a sewage-disposal plant generally backs up sludge into sewer mains, where it hardens, necessitating extensive cleaning and repairs. In addition, there is the cost of remedying actual physical damage to the plant and of cleaning and disinfecting flooded-area property near inundated treatment works. Control of flood waters, therefore, contributes to the assurance of continued operation of treatment plants.

(2) Diminution of pollution load. - By keeping streams in their normal channels, operation of flood control works results in less flooding of sewers, outhouses, cesspools, septic tanks, and refuse dumps, with less of their wastes reaching streams. The public hearing held at Waterbury in connection with this report brought out testimony that unsanitary nuisances result during high water at Ansonia, Connecticut. Polluted Naugatuck River waters, from upstream as well as local sources, invade sections of the city, creating conditions endangering the public health.

(3) Sedimentation in storage basins. - Storage of water in reservoirs results in a settling action, reducing the content of suspended solids. If there are pollution sources upstream, a reservoir pool lessens the content of contaminating suspended material, rendering the water more capable of bearing downstream pollution loads.

Little sedimentation would occur at reservoirs operated for flood control alone, since pools would normally be drawn down.

(4) Aeration. - Through aeration provided at outlet structures, some increase in dissolved oxygen content may be expected at flood control dams. In most cases water discharging from flood control reservoirs will be saturated with oxygen, allowing the oxidation of a maximum quantity of wastes to less objectionable substances.

(5) Benefits to water supplies. - Flood control will decrease health hazards occasioned by contamination of municipal and private water supplies through direct flooding, rupture of mains, and cross connections in flood areas. In the clean-up periods following recent floods, State and local health departments required special precautions before use of flooded ground-water supplies could be resumed.

b. Pittsfield Channel Improvement. - In addition to the flood control benefits, the channel improvement proposed by local interests at Pittsfield, Massachusetts, will provide some sanitation benefits through lessening of inundation by the waters, which receive pollution from upstream sources at Hinsdale and Dalton.

25. POLLUTION ABATEMENT BY CONSERVATION STORAGE. - Through dilution provided by conservation storage, the concentration of objectionable wastes may be reduced to a degree comparable with partial treatment. Dilution alleviates objectionable conditions, and, if conservation storage can be provided at a low cost per acre-foot, it may be desirable as an additional measure, especially during the time until the construction of needed treatment plants can be financed. On the Housatonic River operation of sewage-disposal plants, serving most of the population centers, obviates the necessity for furnishing added low-water flow for pollution abatement purposes. Furthermore, the health departments of Massachusetts and Connecticut, in order to

improve the recreational value of the Housatonic Valley, desire not only a lessening of the concentration of wastes by dilution but the removal of organic solids by treatment. The situation is different on the heavily polluted Naugatuck River. Conditions along this stream are more serious than could be remedied through dilution alone. Whereas a flow of 5 cubic feet per second per thousand of sewage-contributing population is needed to avert nuisance conditions, only 2.9 cubic feet per second could be made available through ideal conservation of Naugatuck River flow. Conservation storage can be provided at the Thomaston site, recommended for flood control in the main report. While any increase in low-water flow would alleviate the present critical conditions, no complete solution of the pollution problem can be found through conservation storage at Thomaston. Evaluation of benefits for pollution abatement by conservation storage to increase low-water flows does not warrant the construction by the United States of multiple-purpose reservoirs for this use. State and local governments may find it warranted when combined with other purposes and local advantages. Pollution benefits from Thomaston Reservoir would accrue exclusively in Connecticut, mainly along the Naugatuck River from Thomaston to Derby.

Summary and Conclusions

26. SUMMARY.

a. The Housatonic River is in fairly good sanitary condition. There is complete treatment of 59.3 percent of the domestic wastes originating in Massachusetts and 57.5 percent of those from New York. The percentage of treated wastes in Connecticut is also high, until the Naugatuck River is reached. In the entire Housatonic Watershed, 33.2 percent of the population is sewered with treatment, 41.0 percent sewered without treatment, and 25.8 percent unsewered with rural disposal methods.

b. Although no sanitation standards have been set for the watershed, past usage has designated the Housatonic River as a recreational stream; the Tenmile and Shepaug Rivers as water-supply sources; and the Still and Naugatuck Rivers as industrial streams.

c. Present sanitary conditions permit all communities to obtain adequate surface water supplies from within the watershed. The surface and ground waters of the basin are low in iron and higher in hardness than other New England natural waters.

d. While the Housatonic River is generally in good sanitary condition, there is sufficient pollution to prohibit its use for water supply without purification. It is the largest potential source of water supply in southern New England. The Tenmile River in New York is used only for the auxiliary water-supply of a State institution. It has been studied as a probable extension for the metropolitan water supply of New York City, and is the nearest available development remaining. Past utilization of the Tenmile Watershed has been impeded by interstate complications.

e. Although no final agreements to accomplish pollution abatement have been entered into by the three States concerned, it is evident that some interstate cooperation is necessary to effect complete control of pollution on the Housatonic and Tenmile Rivers. At present some municipalities, having treatment plants, continue to feel the results of upstream, out-of-state pollution. The rivers entering Connecticut from Massachusetts and New York are, however, not seriously polluted in the Housatonic Watershed.

f. The largest communities having sewage-disposal plants are those at Pittsfield, Lenox, and Stockbridge, Massachusetts, and Danbury, Torrington, and Watertown, Connecticut. As indicated on Plate No. 1, appendix E, there are several other treatment works, operated at communities and institutions.

g. The Naugatuck River, because of its heavy population density and industrialization, is the most polluted stream in Connecticut.

Treatment plants are urgently needed and the State is striving to effect needed installations to serve Waterbury, Naugatuck, Ansonia, Derby, and Shelton. Financial conditions are such that there is no immediate prospect of construction of these necessary improvements.

h. The industrial waste situation is serious along the Naugatuck and Still Rivers. Over 11 million gallons per day of trade wastes are discharged into the Naugatuck River from numerous manufacturing centers. The principal industries are metallurgical, with brass manufacture predominating. While extensive research has been carried on by the Connecticut State Water Commission and other agencies, no commercially satisfactory method has been evolved to date, and the State, lacking suitable methods to suggest, has been unable to urge trade waste treatment for metallurgical wastes. Some of the pollution entering the Still River at Danbury and Bethel has recently been removed through treatment, but there still remains a sizeable volume of untreated hat factory wastes entering the stream. For other types of industry, there are numerous treatment processes operating in the Connecticut portion of the watershed.

i. With population centers separated and some dams and natural rapids interspersed, there is some opportunity for self-purification between pollution sources on the Housatonic River. No such chance for improvement exists on the lower Naugatuck River.

j. Disposal of refuse by dumping into streams or upon river banks below high-water level, in violation of State and local ordinances, is a general practice at some industrial plants and in certain municipalities. An unsanitary and, from the standpoint of floods, dangerous condition has resulted in Danbury from gradual encroachment and filling in of the Still River channel by illegal deposition of refuse.

k. Streams in the Housatonic River Watershed have experienced extremely low flows which have, at times, accentuated nuisance conditions.

l. Operation of flood control reservoirs would provide numerous incidental sanitation benefits, such as (1) protection of sewage-treatment plants, (2) diminution of pollution load picked up by high flood stages, (3) sedimentation in storage basins, (4) aeration at outlet structures, and (5) benefits to water supplies.

27. CONCLUSIONS.

a. Municipal sewage-treatment plants are needed at the following sewered communities, listed in downstream order: Dalton, Hinsdale, Great Barrington, and Lee, Massachusetts; New Milford, Thomaston, Waterbury, Naugatuck, Ansonia, Derby, and Shelton, Connecticut. The last five cities and towns, all located on the Naugatuck River, constitute a major problem. Waterbury is the largest city in western New England with no sewage-treatment facilities. The Town of Naugatuck has agreed to provide treatment for its wastes as soon as similar action is undertaken by Waterbury. Ansonia, Derby, and Shelton, having failed to concur on construction of a joint treatment plant, approved by the State, are now planning three separate units.

b. Formulation of interstate agreements among Massachusetts, New York, and Connecticut with the ultimate objective of setting purification standards for the Housatonic and Tenmile Rivers is desirable.

c. Laws enabling Massachusetts authorities to force cessation of pollution, prevent new sources, and establish regulations for pollution abatement and control are needed. The pollution laws enforced in New York and Connecticut are satisfactory.

d. The Housatonic River Watershed pollution problem can be effectively solved only through treatment of wastes from sewered communities and industrial zones.

e. While the comprehensive pollution abatement program resolves itself into treatment of wastes rather than provision of dilution, conservation storage for augmenting low-water flow would be beneficial, particularly on the Naugatuck River, if it can be made economically available.

f. Expenditures by the United States for added storage for pollution abatement in flood control reservoirs are not justified by an evaluation of the benefits therefor. Additional local benefits and advantages may warrant provision of such storage by local or State interests. Physical conditions at the Thomaston dam site, recommended for flood control, are such that added storage for conservation can be provided.

g. Continuation of research to develop methods of industrial waste treatment is commended, and with improvement in the economics of waste treatment, other plant owners should be encouraged to make installations voluntarily. In the abatement of Naugatuck Watershed pollution, it is of importance that a suitable method be found for lessening the harmful effects of metal wastes and, if possible, recovering some of the valuable metals now being discharged in solution. As rapidly as finances permit, treatment plants, either individual or centralized, should be established for industries releasing offensive wastes or contaminating waters.

h. Periodic sampling and analysis of river waters in Massachusetts and Connecticut furnishes the evidence necessary for properly controlling the quality of waters. Continuation of such programs is recommended.

i. To abate pollution caused by dumping of refuse into streams, the town, city, and State authorities should provide garbage reduction or refuse incineration plants or suitable dumping grounds. Regulations for refuse disposal and, when necessary, prosecution of violators are also suggested. This is a matter of importance along the Still River in Danbury, Connecticut.

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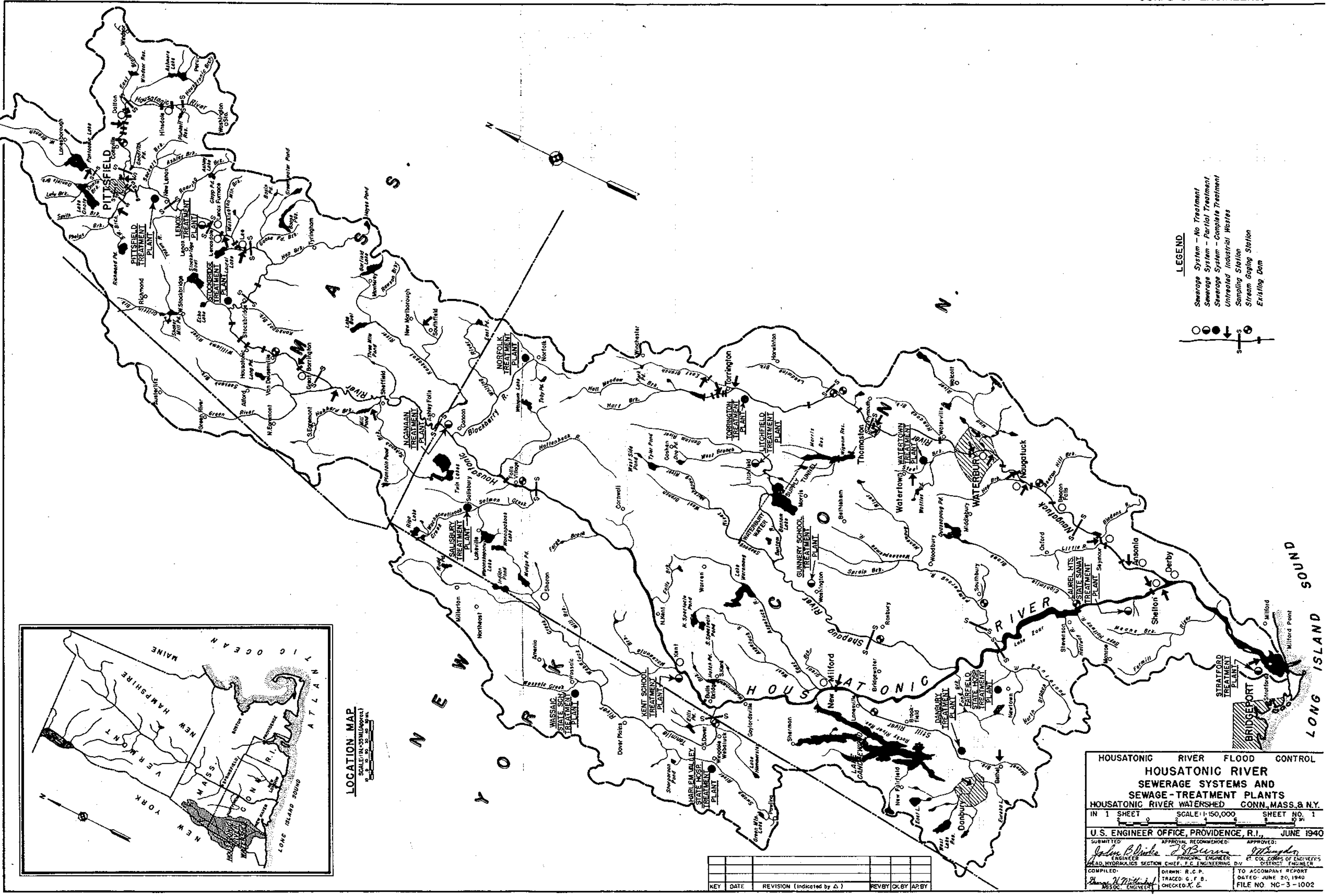
LEGEND
Sewerage System - No Treatment
Sewerage System - Partial Treatment
Sewerage System - Complete Treatment
Untreated Industrial Wastes
Sampling Station
Stream Gaging Station
Existing Dam
PITTSFIELD
PITTSFIELD TREATMENT PLANT
LENOX TREATMENT PLANT
STOCKBRIDGE TREATMENT PLANT
N. CANAAN TREATMENT PLANT
NORFOLK TREATMENT PLANT
SALISBURY TREATMENT PLANT
TORRINGTON TREATMENT PLANT
LITCHFIELD TREATMENT PLANT
WATERTOWN TREATMENT PLANT
WATERBURY
GUNNERY SCHOOL TREATMENT PLANT
LAUREL HTS. STATE SANAT TREATMENT PLANT
WASSAIC STATE SCH. TREATMENT PLANT
KENT SCHOOL TREATMENT PLANT
HARLEM VALLEY STATE HOSP. TREATMENT PLANT
DANBURY TREATMENT PLANT
FAIRFIELD STATE HOSP. TREATMENT PLANT
STRATFORD TREATMENT PLANT
BRIDGEPORT
HOUSATONIC RIVER
LONG ISLAND SOUND
NEW YORK
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LOCATION MAP
HOUSATONIC RIVER FLOOD CONTROL
HOUSATONIC RIVER
SEWERAGE SYSTEMS AND
SEWAGE-TREATMENT PLANTS
HOUSATONIC RIVER WATERSHED CONN., MASS. & N.Y.
IN 1 SHEET SCALE: 1:150,000 SHEET NO. 1
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